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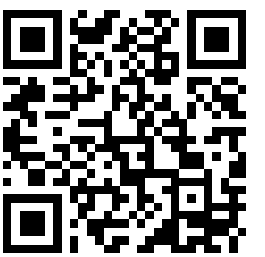

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April 1915 ~~Vol. I, No. 9~~

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Entered as second-class matter at the post office, at Boston, Mass. Published monthly during the college year by the students of the Massachusetts Institute of Technology. Publication office, Technology Union Building, 42 Trinity Place, Boston. Harvard Editorial Office, 218 Pierce Building, Cambridge, Mass.

Mail Address: Technology Monthly, M. I. T., Boston, Mass.

Subscription rate, $1.50 per year; 25c. per copy. Advertising rates upon application.

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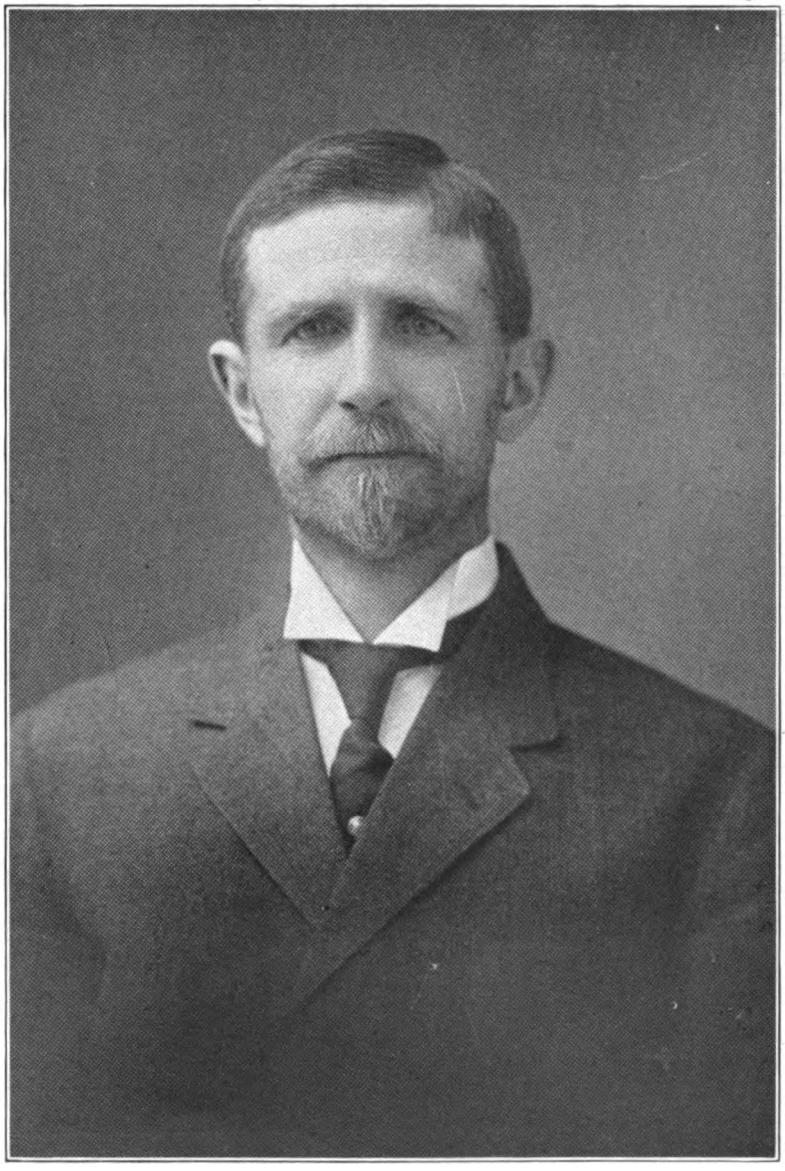

ROGER W. BABSON, M. I. T., '98

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THE TECHNOLOGY MONTHLY
AND HARVARD ENGINEERING JOURNAL

VOL. II BOSTON, MASS., APRIL, 1915 NO. 1

HOW TO ANTICIPATE BUSINESS CONDITIONS

By ROGER W. BABSON, M. I. T., '98. President, Babson Statistical Organization

Mr. Babson's articles on Business Problems have appeared from time to time in The Saturday Evening Post

THE foundation of the work described in the following pages arose from the fact that wherever I went I found that the great majority of people, manufacturers, bankers, and investors, were wholly unprepared for the great economic changes which the country periodically encounters. Being unprepared they were always on the wrong side, and lost heavily. On the other hand, a certain few were always prepared and reaped the benefits therefrom. In talking with the business men in various sections of the country, I find they entirely ignore two very important facts, viz:

First, they feel that their business depends simply upon conditions in the territory in which they operate. For example, a large local jeweler in Cleveland states that he sells only in Cleveland, and thus he is interested only in conditions in Cleveland, while the manager of a shoe jobbing house in Boston endeavors to convince me that he is interested only in New England conditions. They are, however, making a great mistake.

Second, the great majority of our manufacturers and merchants feel that they are interested in the progress of only their own line of trade. The majority of such men are careful readers of their own trade papers, but they spurn the idea of endeavoring to keep in touch with the conditions in other lines, or of studying statistics of a general nature. This also is a distinct mistake.

There are two points that should never be forgotten, (1) that each business, even though apparently local, is dependent on the business of the entire country, and even of the entire world; and (2) that each business is dependent on the conditions of business in other lines. When the business men of America study statistics from this point of view, the United States will make a great advance. Moreover, it is due very largely to the fact that the average business man does not recognize these fundamental principles, that he is groping in the dark, and looking toward a Sherman Act, a monetary commission, some tariff readjustment, a ship-subsidy, or something else of an

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artificial nature to solve his problems. When our business men appreciate the importance of fundamental statistics, most of our national problems will be solved.

HOW THE MERCHANT CAN KEEP IN TOUCH WITH BUSINESS CONDITIONS THROUGHOUT THE COUNTRY

I have said that the business man should keep in touch with conditions all over the country. The reason for this is very obvious. Take the case of a large department store in some city like Pittsburgh. All will readily admit that the trade of this department store depends very largely upon the condition of business in Pittsburgh. It will also be granted that the conditions in Pittsburgh during the coming year depend upon the condition of the steel, the iron, the cement, and the other leading industries centered in that city. The condition of these industries, however, depends not on the local Pittsburgh conditions, but on conditions throughout the entire country.

Therefore, the trade of this local department store which sells only to Pittsburgh people, depends upon general as well as local conditions. The conditions in the Northwest and the Southwest determine whether or not the railroads in those distant territories will be double tracked, necessitating the ordering of steel rails from Pittsburgh. The crops of the great Central West affect the business of its great cities, which in turn settles the question as to whether or not new structures will be erected during the coming year, which in turn influences local Pittsburgh conditions. Tell me what the conditions *outside* of Pittsburgh will be, and I will tell you what the conditions *in* Pittsburgh will be. To ascertain these conditions, resort must be had to statistics.

For some years my organization has been supplying detailed reports from the hundred or more leading cities of the country, stating as briefly as possible whether business is good or poor, improving or declining, or at a standstill. Such reports are mailed to clients twice a month, thus showing manufacturers and merchants the actual business conditions in all sections of the country. We find, however, that even these do not fully meet the needs of the sales manager and the manager of the credit department. Therefore, two maps of North America * are issued each month, both of which are usually mailed to the president or general manager of the corporation which employs us. One of these maps is what is known as the "Optimistic" or Sales and Advertising Map, showing where business is best, where failures are fewest, where the crops are the most promising, and where various other conditions are such as to attract trade. The president turns over this map to his sales manager and advertising man so that the routing of the salesman, the distribution of the advertising and all other work connected with the extending of sales may be centered on that part of the country where the greatest opportunity exists. In other words, such a map is primarily to afford the head of the business a bird's-eye view of the conditions throughout the entire country, and the statisticians *are simply supplying suppressed news months before it appears in the public press and magazines.*

* South America is now being covered in the same way, and a business map of the world is also issued in connection with this South American Service.

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Supplementing this map, another is prepared and sent to the head of the corporation. This may be called the "Pessimistic" or Credit Map. It shows where business is poor, where the crops are uncertain, where failures are on the increase, and where credit conditions should be especially watched. Here again the president can make still further use of this map by turning it over to his credit department, enabling this department to avoid the unfair and harmful system of "shutting down" on everybody and all sections of the country in the same proportion. Instead, the credit department may contract credits in one part of the country and possibly expand them in another section in a common sense and legitimate manner.

WATCHING CONDITIONS IN OTHER LINES

In the same way, statistics are used to keep business men informed as to conditions in lines other than their own. In order to keep themselves informed as to general conditions, manufacturers and merchants now study at regular intervals certain statistics in sheet form. These statistics include figures on New Building, Bank Clearings, Business Failures, and Immigration, all of which are of distinct aid in accurately determining mercantile conditions.

Next appears a group of statistics on monetary conditions: the "Loans" of the banks and the "Deposits" of the banks are given, together with the "Cash" held and the "Surplus Reserve." A comparison of the latest Comptroller's Report with other Comptroller's Reports of the same season of the year is given. I always say to those who borrow money that there are two items which should be constantly watched,—the percentage of loans to deposits and the percentage of cash to loans. Under the same group of statistics on monetary conditions are the figures on foreign trade, including "Imports" and "Exports" and the "Balance of Trade" figures. These show merchants which way the tide is running; so at a glance they can note the change the moment the tide turns. There are also tables on "Money Rates," both domestic and foreign; for the relation between the two is intensely valuable in forecasting changes in credit conditions.

The investment situation is portrayed by such subjects as "Transactions in Securities," the "Average Prices of Stocks," the "Average Prices of Bonds," the "New Securities Listed," the "New Corporations Organized," the latest "Railroad Earnings," and "Idle Car Figures," etc., etc. Then, of course, such sheets contain the latest statistics of the crops, with the estimated acreage, condition, and production. Not only do they afford valuable information relative to winter wheat, spring wheat, corn, cotton, but also statistics relative to pig iron, copper, etc.

All this work which I have thus far mentioned is of value in keeping the business man acquainted with actual conditions existing throughout the country, but statistics have a far greater purpose than simply that of enabling business men to learn what the present conditions are; *they help him to anticipate what is coming.* By watching business conditions in all sections and in all lines, by doing this every week or two in order to keep in touch with these movements, and by ascertaining the direction and rate of

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speed at which the various waves of prosperity and depression are traveling, any man may anticipate very closely future changes in business.

This brings me to a brief description of the Composite Plot of Business Conditions, so called.

The Law of Action and Reaction is one of the most fundamental laws of the universe, underlying as it does all sciences, from astronomy to chemistry. I do not need to go into details as to how this law was developed in its practical applications by Sir Isaac Newton, its great expounder. Its mechanical applications are already familiar to every engineering student. The great philosopher understood full well that it governed affairs in many other realms. McLaurin in his famous treatise entitled, "Sir Isaac Newton's Philosophical Discoveries," discussing Newton's ideas concerning spiritual manifestations, and referring to the Deity, even went so far as to say:

"The establishing of the equality of action and reaction, even in those powers which seem to surpass mechanism, and to be more immediately derived from Him, seems to be an indication that those powers, while they derive their efficacy from Him, are, however, in a certain degree circumscribed and regulated in their operations by mechanical principles."

The same idea can be worked out in a psychological way. The famous professor, Wilhelm Ostwald, formerly of Leipzig University, recently stated his belief in the application of this law of Action and Reaction to economic changes in somewhat the following language:

"While in the case of a bridge, steamship, or an electrical plant it has been possible to foretell what the results of their operation will be, it is somewhat more difficult to foretell economic matters. Why? The laws of economic processes are not well known, but the laws no doubt exist and are being hidden behind manifold individual phenomena." Prof. Ostwald then called attention to the cycle or wave movement which economic affairs have always portrayed, and goes on to affirm that the economist and statesman must learn the laws governing such matters, in order to anticipate future business conditions.

The Composite Plot herewith attached shows in a graphic form how the law of Action and Reaction may apply to the business of a nation. Various charts and tables have been prepared by different individuals in order to enable manufacturers, merchants, and investors to take advantage of the economic cycles intelligently. With the exception of "Area Charts," so called, all of this work *either has ignored one of the two factors—time or intensity—or else has not properly considered the changed conditions due to a country's growth or decline.* These criticisms, however, do not apply to the Area Theory, upon which the annexed chart is based. The outline of the black areas (which will be referred to as the "curve") is determined by reducing to common index numbers the latest figures on various economic indicators, such as bank clearings, money rates, new building, railroad earnings, politics, crops, etc., already enumerated in this article.

The altitude of the area represents the intensity of the business movement, while the horizontal length of the area represents its duration. On account of this fact, a diagnosis of an area plot and a consideration of the area's shape aid one in determining how long it will be before a change in conditions

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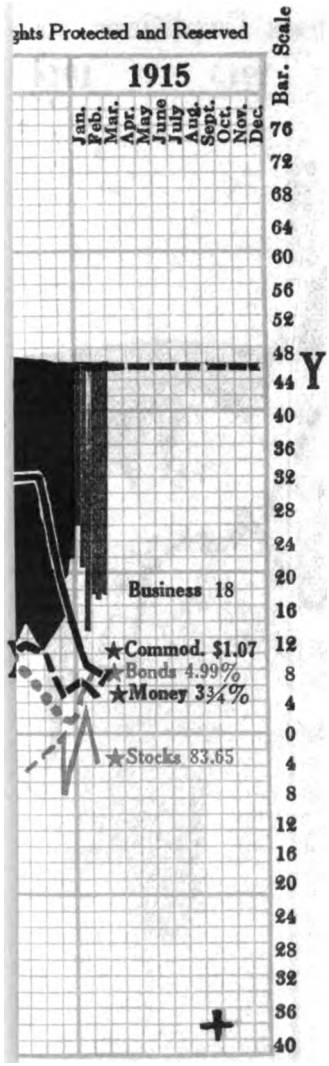
may be expected. If an area is one of considerable altitude, the change may be expected to take place very much sooner than if the altitude were not so large; while, on the other hand, shallow

al growth to which business is entitled, but when crops are poor, politics uncertain, or the country has met with some great disaster, the X-Y line slopes automatically downward



Explanation of the Composite Plot

The large black areas are formed by combining and plotting the Desk Sheet figures on New Building, Crops, Clearings, Immigration, Surplus Reserve and Money (adjusted scales), Failures, Commodity Prices, Railroad Earnings, Stock Prices (adjusted to shares traded), and Politics (when necessary) in order to give a Composite Plot of business conditions in the United States. New building was substituted for iron production January, 1910; idle cars for railroad earnings March, 1911, but railroad earnings were resumed in December, 1914, when idle car reports were discontinued; revised scales for bank clearings and failures were introduced Jan. 1, 1912, and for monetary figures August, 1912. Surplus reserves, since November, 1914, have been estimated in accordance with money rates. The line X-Y represents the real prosperity of our country's business, the slope being changed whenever there is sufficient evidence of a change in the trend of conditions. Based on the economic theory that "action and reaction are equal" when the two factors of time and intensity are multiplied to form an area, the sums of the areas above and below said line of normal growth X-Y must, over sufficiently long periods of time, be equal, provided the line X-Y is properly located and enough subjects are therewith included, with all properly weighed and combined.

All prosperity areas need not necessarily be equal, although areas of the same cycle tend to be equal in *area*, if not in shape. Area E, which is now being formed below the line X-Y shows the normal reaction from the period of overexpansion represented by Area D, the net result of the 1911-12 movement having been approximately neutral. It, however, should be remembered that this present period, area "E," may be of an entirely different shape from anything heretofore witnessed and still contain a proper area. Knowing that the areas tend to balance, one can always estimate the length of any period by watching each week its height or "rate of flow," which shows how rapidly it is being consumed. The red solid line represents the average price of stocks, the red dotted line the average trend of bonds, the solid black line represents the average interest rate of prime paper, and the broken black line the average prices of commodities excluding foodstuffs. A study of these lines shows that the high points of the stock market have come about the beginning of the prosperity areas and the low points have come about the beginning of the depression areas, that low money rates and high bond prices have come about the end of the depression areas and high money rates and low bond prices at about the end of the prosperity areas.

To use this Composite Plot in connection with one's own business, the observer should plot his own sales thereon and note what portion of the respective areas have been consumed when his own sales were greatest or smallest. When using this plot for any purpose, it should be remembered that it refers to the *minor* cycles and not to the *major* cycles shown by the dotted line on the stock-market chart which appears opposite page 31 of the text book, "Business Barometers," and also that this work in its present state should be watched in conjunction with other data and not be treated "as a rule of thumb" and substituted for independent thought and judgment. Moreover, owing to the increased study of fundamental conditions these areas should slowly decrease in size, "E" being smaller than "D." The slope of the line X-Y must always be estimated for the latest year and is thus shown *dotted and undetermined* for 1915. After the close of 1915, however, we shall know better what its slope should be and will then indicate the same with a solid back line in accordance with clearings, etc., subject only to revision at the end of the cycle In fact, it may be necessary to revise portions of the Plot from time to time, as conditions change and new data are secured.

good and politics constructive, the X-Y line automatically slopes upward enough to compensate for this additional growth to which business is entitled, but when crops are poor, politics uncertain, or the country has met with some great disaster, the X-Y line slopes automatically downward edge of the real facts in the case.

*Complete details of how the Composite Plot is made and how the X-Y line is located will be gladly mailed, upon request, to any reader.

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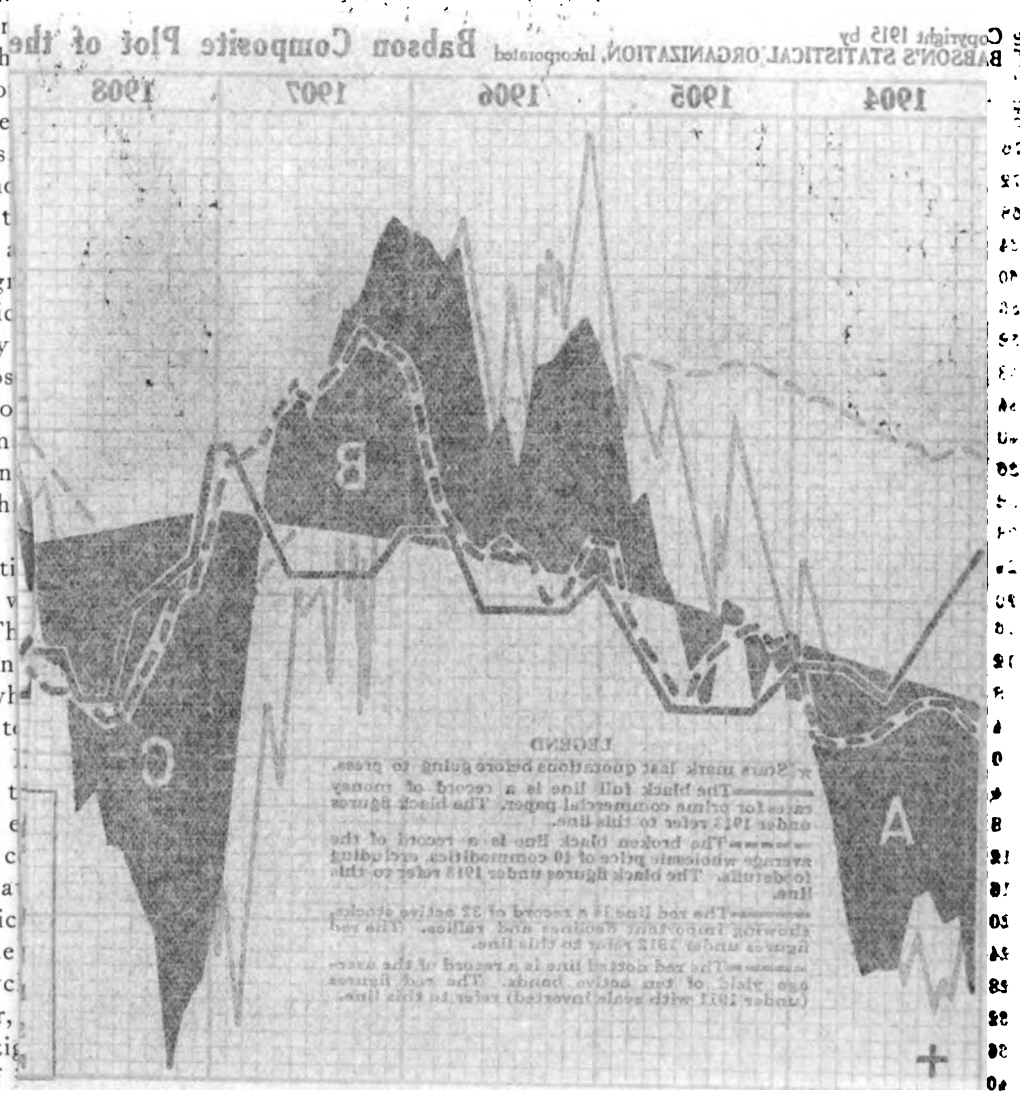
This brings me to a brief description of the



Action changes in somewhat the following language:

"While in the case of a bridge, steamship, or an electrical plant it has been possible to foretell what the results of their operation will be, it is somewhat more difficult to foretell economic matters. Why? The laws of economic processes are not well known, but the laws no doubt exist and are being

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may be expected. If an area is one of considerable altitude, the change may be expected to take place very much sooner than if the altitude were not so large; while, on the other hand, shallow areas are likely to continue for some time.

The X-Y line, which is the oblique line dividing the "curve" into areas, is based on the growth of the country; and if such variables as politics and crops were constant and there were no disturbing natural forces, such as great earthquakes and floods, the X-Y line could be considered as fixed. These uncertain forces should be considered, however.

In the plots published by the Babson Organization, the curve is located once a month and the X-Y line once a year; but both theoretically change every day. The curve changes in accordance with the various economic movements referred to, while the slope of the X-Y line changes in accordance with the net growth of the country, and thus is dependent upon crops, politics, etc. Practically speaking, the curve is the combination of a large number of subjects and represents monthly activity, while the X-Y line is based on the net growth of the country as determined by previous areas. * Each year the slope of this X-Y line is temporarily fixed by a study of bank clearings and other factors. At the end of each cycle, however, an arbitrary correction is made, if necessary, by slightly raising or lowering the X-Y line, the object always being to *keep its slope true to conditions of actual net growth.* When crops are good and politics constructive, the X-Y line automatically slopes upward enough to compensate for this additional growth to which business is entitled, but when crops are poor, politics uncertain, or the country has met with some great disaster, the X-Y line slopes automatically downward.

The fundamental principle concerning the Area Theory is, then, as follows: *if the line X-Y truly represents the net growth of a nation and if the outline of the black area truly represents the actual growth, then the sums of the areas above and below the line X-Y must, over sufficiently long periods of time, be equal.*

Such, very briefly, are the salient factors employed in anticipating future conditions of a given country. If, during a period of depression and discouragement, the Composite Plot shows distinctly that the area has advanced far enough to indicate that a period of improvement preparatory to an area of prosperity is at hand, investors buy securities, merchants buy goods, and bankers extend loans. On the other hand, during a period of great prosperity and extravagance, when everybody is over-extending, the Composite Plot invariably suggests that a period of decline is in order, and this is the signal for wise investors to sell their securities for cash, for merchants to reduce their merchandise and credits, and for bankers to reduce loans or place them "on call." This is the only safe and sensible way for anyone to do business. Moreover, I feel that each one engaged in such a study is rendering a great service to his nation by always having "his feet on the ground" and by working from an exact knowledge of the real facts in the case.

*Complete details of how the Composite Plot is made and how the X-Y line is located will be gladly mailed, upon request, to any reader.

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NIEMAND ZU HAUSE

NIEMAND ZU HAUSE, a vaudeville performance, to be given by the students of the Massachusetts Institute of Technology under the auspices of the Institute Committee in Huntington Hall on the evening of Friday, March 19, deserves the hearty support of every Tech man, for the production is an effort to raise funds for the Athletic Association and enable the various Tech teams to complete the schedules arranged for the remainder of this school year.

Athletics at the Institute have been growing yearly. With the prospect of the new home across the Charles in the ever nearing future, efforts have been made to begin and develop new branches of sport so that when the New Technology does open its doors to the world and thus give greater opportunities for the advancement of athletics, the student body will not be unprepared but will have already obtained a start along these lines.

But unfortunately this athletic development and the financial means for sustaining it have not progressed hand in hand. The former has far outstripped the latter. There is no athletic tax in the Institute. There is not even the possibility of student subscriptions to the Athletic Association. The only source of funds is contributions from other branches of student activities and from interested Alumni and from extremely meager gate receipts.

Therefore, realizing the necessity, the Institute Committee makes at this time an appeal to the Student body for co-operation in athletic support and gives this opportunity to each undergraduate to give his mite toward the foundation of future Technology success in the realm of intercollegiate sport. Come to Niemand Zu Hause! Come and enjoy the entertainment provided by your classmates. Come and feel that you have done your small part in making the life of Institute athletics surer and its future success more certain.

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NIEMAND ZU HAUSE

Friday March 19th

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THE FIRST WRECK

By ALECK W. YEREANCE, M. I. T. '11

THE Chief came into the office an hour earlier than his usual Sunday time. He appeared to have dressed hurriedly. At my "Good morning," he said:

"What do you hear from the wreck?" My feet and the week-old *Times* I had been reading came to the floor together.

"What wreck?"

"The '20' and '23' came together head on—didn't you hear about it?"

He reached for the desk phone and called for the hospital. My feet and hands had gone cold and something seemed wrong inside my stomach—I felt a weight on the bottom of it. I waited for him to speak.

"Damn that kid, he's too slow—that you, Doc? This is Martin. Say, Doc, we've got a wreck on the railroad. The dispatcher says two men missing and three under the wreck. I want you to go down with a gang on the '94.' She'll leave the yard here in ten minutes. All right? That's the boy."

He slapped the receiver up and turned to me.

"Get Joe's gang from the shop and take the '94' with a couple of flats. Don't wait for running orders,—there's nothing between here and the wreck—it's at Trestle 17. Hustle, but don't go without Doc."

My heart was pounding my ribs like a pneumatic riveter as I ran out of the office and down the hill. Near the foreman's bunk house I saw the "94's" conductor.

"Hey, Red, where's your jack?"

"Charlie's just finished washin' 'er out. Whaddayah want, honey?"

"Where's the '41'?"

"Down on the low level, I guess. No, there's Gillis over there; she must be laid up. What the hell's the matter?"

I reached Gillis as he was passing the cookhouse, walking leisurely towards his room.

"Tom, where's the '41'?"

"Just put her in the shop, sor; they're goin' to pull her fire and do some repairin'."

"Come on, we've got to have her." I pulled him around by his jumper.

"20" and "23" met over by Trestle 17, and there's two men gone and three under the wreck. Get the '41' and two flats and hold them in the yard till I come. Beat it."

He reached the shop one jump ahead of me and grabbed the hostler who was climbing into the cab of the locomotive. By that time I had collected the shop foreman and his gang with two 50-ton jacks, some axes and saws, and a coil of wire rope. Gillis had hooked onto the flats and was looking for me. As the doctor climbed aboard the forward flat, I gave Tom the "Go ahead" and we started.

Three times I repeated to the sober faced man on the cars all the facts that I knew, then went forward and sat down with the doctor. Slowly, oh, so slowly, the little switch engine pushed us over the uneven track and around the sharp "corners" which could not be called curves.

It was in June, a perfect day. The sky was cloudless. I noticed how

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the dark pines along the right of way contrasted with the deep blue sky ahead. Missing! Two men gone and three badly hurt! The "20"—why, that was Zach's engine, and I had seen Zach only thirty minutes before, as I passed the little shack in the yard from which the conductors telephoned to the dispatcher at Camp 4 for their running orders. He was swearing at the phone and I heard him say to his engineer, "The wires must be down, but I won't turn a wheel out of here without orders."

"That's the boy, Zach," I had called to him, laughing at his vehemence, "safety first."

And now he was probably lying under the wreckage, dead! He must have gone without his orders anyhow, and he always rode the pilot beam of his engine. This was our first wreck; there had been derailments, of course, but no real wrecks. On all our cofferdam work, no one had been killed.

We crossed Trestle 18 and Gillis slowed down his engine. Only the sharp exhausts of the "41" and the squeal of the wheels rounding a turn violated the silence of the woods.

Around the curve a man stood on the track. He swung his hands and as we reached him, we stopped. He said nothing.

"Where is it?" I asked. The rest pressed around.

He turned without a word and we followed as he walked back. He moved slowly, like a man deep in thought with no need to hurry. Our train crept along as we walked. Around the next bend we found the wreck.

First a box car, empty, of course, on the rails undamaged; then a gondola, with one truck off and one end resting on the side of the gon ahead. That car was crosswise of the track, and the next had been thrown on its side, clear of the ties. The trucks lay on the other side of the track. Then a flatcar broken to splinters, its rods and brake rigging twisted and tangled, part lying on the tank of the "20," and then the engines telescoped into each other for six feet, their tenders each at an angle of 45 degrees with the horizontal and jammed into the cabs. But no men! Our guide did not stop or speak. We walked around the roof of "23's" cab lying in the ditch and passed the cars of the loaded train. Crushed stone piles lay on the tracks; one car had climbed on another and both had toppled off the track. A pair of trucks blocked our way and we stopped to avoid the jagged end of the side sill of a sand car. Still no men! We passed a steel gondola loaded with coal, dented and derailed, but intact. Then we found them.

In a little open space in the woods at the edge of the right of way a group of our railroad men were clustered about what I knew to be a mineral spring.

Most of those standing were bending over something on the ground; they appeared deeply moved. Not one turned or noticed our approach. Instantly I pictured a couple of men lying mortally hurt and the rest too intent on doing all they could for them to heed us. Pity, and the horror of what we expected to see, prevented our running; slowly but silently we filed through the weeds to the spot.

"Shoot," a hoarse voice cried, and every man jack in our party stopped.

"Shoot," he yelled, "shoot you for six bits, Zach."

On the ground beside the spring, leaning back against a tree, sat Zach.

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Before him on the ground lay a pile of bills and some change. Two soot-streaked trainmen crouched on their hunkies opposite him. The rest watched.

"Come 'ohn, yo' piker, you-all drew $27.65 yesterday, make it a bean and I'll shoot yuh." Then he looked up and saw us.

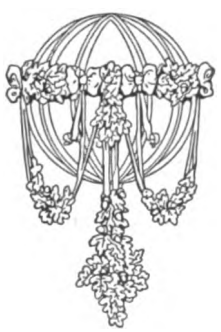
Nobody was dead. Several had bruises and bumps from the "suddin stop," as Gillis put it, when they jumped from the trains to the ground. So Doc patched them up and we started for the River. At Sham's siding the Chief was waiting for us, sitting in his runabout with the "walking-boss," anxious-like, where the road crossed our track.

I jumped down and told him the story, including the crap game.

"Hell," he said, but even at that he seemed a bit pleased. He had seen the wreck.

At Lock 12 a silent, respectful crowd was gathered around the warehouse. Our story relieved the tension, and as I walked up the hill to the office and my *Times*, still feeling a little shaky, I noticed that the men who had been in the wreck were the heroes of the day and the centers of attraction for the Sunday idlers.

The railroad men had the track cleared by ten o'clock. We poured 1044 yards of concrete in the dam that day.



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THE SALEM AND EDISON FIRES AND FUTURE INDUSTRIAL BUILDING CONSTRUCTION

THE VINDICATION OF CONCRETE

By J. P. H. PERRY, H. '03

TWO fires in 1914, one at Salem, Mass., in June, and the other at the Edison Works, West Orange, N. J., in December, have taught the industrial community lessons which the advocates of concrete have been endeavoring to drive home for years. The fires were radically different in their nature, and equally impressive in their results.

The Salem conflagration wiped out some two and one-half square miles of a prosperous town. The biggest single loss was in the plant of the Naumkeag Steam Cotton Company, on the ocean front. This consisted of a group of some sixteen buildings, regarded by the Associate Factory Mutual Fire Insurance Companies as one of their star risks. The buildings were, with one exception, of the highest type of brick and heavy mill construction. The fire protection was supposed to be as nearly perfect as practical experience dictated for this class of construction, a type of building which carries in the average industrial man's opinion about as low insurance as can be bought. There was a complete sprinkler equipment. There were two large fire pumps. The plant was surrounded on three sides by the ocean, supposedly giving a maximum water supply. A full system of standpipes and automatic alarms had been installed, and the plant was one which was operated with conservative care and constant vigilance.

Despite this, and the fact that the scientifically managed insurance companies welcomed the risk, the plant was almost completely destroyed, with a total loss of some three and a half million dollars. The one building not destroyed was a four-story concrete warehouse, located almost in the centre of the plant and subjected for many hours to the temperatures created in the heart of the conflagration. With the exception of some melted wire glass in the windows, and a little scorching of the exterior, there was absolutely no damage to this warehouse.

Not a sprinkler head on the inside went off. There was no damage whatsoever to its inflammable contents, and this concrete warehouse was like a well in a desert, so remarkable was its escape from destruction.

While the textile industry has almost uniformly refused to adopt reinforced concrete construction for its buildings, the directors of the Naumkeag Steam Cotton Company, after this lesson and further careful investigations of concrete buildings, not only on the part of their architects and engineers, but for themselves as well, elected to use concrete in the new buildings which are now under way, at a cost approximating two million dollars. They had learned that even the best slow-burning construction, with all fire-preventive and fire-protection equipment, was susceptible of destruction in case of conflagration, or, for that matter, in case of a severe fire

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TYPICAL VIEWS AFTER THE FIRE AT THE EDISON PLANT

Note the distinct contrast between the effect of the fire upon brick and steel structures (in the foreground), and upon concrete, which underwent the same intense heat*

* Photographs accompanying this article reproduced by courtesy of Association of American Portland Cement Manufacturers, Philadelphia

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in the plant itself. While the cost of concrete construction was somewhat higher, though probably not over 10 per cent in this case, they felt that the protection of having concrete buildings which could not be destroyed was well worth the increased cost.

The other fire referred to, viz., in the Edison Works in West Orange, was of an entirely different nature. Here was a case where every elemental principle of fire protection and prevention had been ignored. There were no sprinklers and no system of fire pumps; scarcely any water supply; no fireproof windows or wire glass; few, if any, fire walls, and only scattering fireproof partitions, sadly lacking in fire-doors.

The buildings were filled and, one might almost say, crowded, with the most highly inflammable contents imaginable. Celluloid, wax, varnish, paint, rubber, wood, in dangerous combination, burned in some cases for nearly four hours before any water reached the fire. In fact, it is stated that it was over two hours before any water was gotten inside the buildings. Some seven large concrete buildings, from four to six stories in height, had to stand this most intense fire.

The writer possesses pieces of fused concrete with particles of melted copper mixed in a concrete clinker. It is a well-known fact that the temperature in the kilns where cement clinker is made runs up to 2,800 degrees, and, to obtain fused concrete with copper, melted brass, melted castings, etc., means that temperatures were maintained ranging from 2,500 degrees to 3,000 degrees for long periods of time.

In spite of what is believed to be the most severe fire test modern buildings have to stand, practically every one of the concrete factories came through with only moderate damage. It is true that the three upper stories in one end of one building collapsed. The collapse stopped at the fourth floor, however, this floor having to carry a terrific overload in the materials which fell upon it. The three collapsed stories contained a department where the very heaviest machinery in the plant was located, and where excessive temperatures maintained for several hours. Elsewhere in the plant many of the columns have been shattered, but the buildings are standing, and most of them are already housing new machinery, and manufacturing is under way. The damaged portions can in practically every case be repaired without very great expense.

The opinion of many engineering and building experts who visited the plant is practically unanimous that no other practical method of building construction known today would have stood up under this fire test. Brick and mill construction would have been a total loss, brick and fireproofed steel as ordinarily built would have collapsed entirely; that concrete is standing at all is an engineering wonder.

A lay man first visiting the ruins of the Edison Works would very likely say that concrete had failed. As a matter of fact, after several hours of study of what concrete actually did, and an appreciation of the test it was put to, one feels that it is the most remarkable example of the fireproofness and permanence of this form of construction.

These fires, taken together, almost dictate the use of reinforced concrete in one form or another for industrial buildings. Steel construction properly fireproofed will stand most fires, but it is doubtful if it would have met either the Salem or the Edison tests. Brick and mill construction is, at best, only slow-

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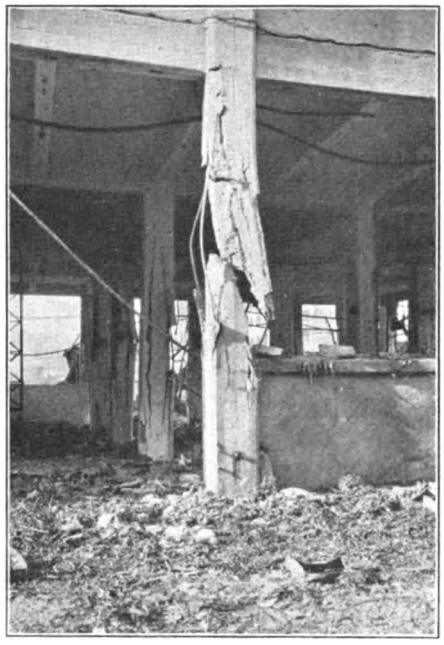

Shattered Concrete Column Held by Reinforcing Rods

burning, and where reinforced concrete can be gotten at from 10 per cent to 15 per cent less than structural steel, and at not over 10 per cent, on fair-sized operations, more than mill construction, it is hard to understand its rejection.

Besides strengthening the claims of the advocates of reinforced concrete as regards the adoption of this material for factory and warehouse buildings, these two exceptional fires taught the observer many other valuable lessons, among which the following seems to be the most striking:

It is nothing less than folly to build a factory—or for that matter any building—of fireproof materials and then ignore the fact that a building is fireproof only as is the stove. The contents themselves are no more free from a blaze in a fireproof box than they are in a wood shed. It is not sufficient to build footings, columns, walls, floors, beams, and girders of concrete,—and then to put in wooden window frames and sash, stock doors, wooden or plaster partitions, and to leave elevator and stair wells unprotected or open from floor to floor. Furthermore, manufacturing departments or storage rooms containing highly inflammable materials cannot be placed in uninterrupted proximity to other similar departments, nor is it proper to fail to provide methods of putting out a fire as soon as it starts.

An industrial building to be an economic success should be designed in accordance with the following principles:

1. The structure must be fireproof, which means one of two things, all reinforced concrete (the walls may be of brick) or structural steel fireproofed with concrete (either stone or cinder)

2. All openings between floors must be enclosed with fireproof partitions fitted with automatic firedoors and,

Effect of Heat on Plastered Concrete Column

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preferably, the stairways should have smokeproof vestibules.

3. Floor areas in excess of 10,000 square feet should be divided by fire walls, also protected with firedoors.

4. Window openings should be equipped with metal frames and wire glass.

5. Unless the nature of the contents forbids, a sprinkler system should be installed to control the fire as soon as it starts. In connection with this sprinkler system should be standpipes and reels of hose and adequate water supply.

6. A firefighting force should be developed in the plant together with a proper system of fire pumps and fire drills.

The Edison fire seems to indicate the advisability of using round columns and flat ceilings so as to make it as difficult as possible for the penetration of heat into the fireproofing material enclosing the columns or supporting the floors.

The state of New York recently enacted a law forbidding the construction of factory buildings over 4 stories in height of anything except fireproof materials. This legislation is wise and far-reaching in its effects and should impress the industrial executive with the serious needs or warehousing buildings. The economic of properly designing his manufacturing waste in this country is stupendous and the loss of human life in firetraps is appalling. Both of these losses can be largely eliminated by proper appreciation of the lessons taught at Salem and West Orange.

RESULT OF FAILURE OF A ROOF

Two upper stories collapsed, bringing their own weight and that of heavy machinery all onto the third floor, which successfully withstood the strain. Cause of failure unknown, although an explosion is suspected. Note steel reinforcing exposed

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AN OLD SONG

Tune — "On the Road to Mandalay."

I.

After months of patient waiting and of moiling ev'ry day,
Engineers are apt to hear the words, "I cannot raise your pay;
For the times are hard and engineers are plenty, so they say;
I am sorry, my dear boy, but I can't elevate your pay."

Chorus:

Oh! I want a raise of pay,
'Tis the burden of my lay;
I am cussed tired of waitin',
Gettin' older ev'ry day.
Oh! I want a raise of pay,
For my hair is gettin' gray
And the years go by like thunder
Waitin' for that raise of pay.

II.

We've been up against the boss to get our rights from time to time,
But we never moved his stony heart to grant a blessed dime.
"Now if you don't like your job, my son, you know what you can do;
So fade away and work, I have no time to talk to you."

Chorus:

III.

Oh! I know the boss is tired of all our noise and all our din,
And he's often tempted to cry out, "Oh! hold your blooming chin."
But we've organized a Club and our demands are very clear,
Just raise our pay at once and then from us you'll never hear.

Chorus:

IV.

Some of us have gone and married and some others want to be,
But we do not dare to try to raise a growing family;
Because the scale of pay is low, we're waiting ev'ry day
To hear the welcome words, "Oh! yes, my boy, I'll raise your pay."

Chorus:

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ARE THESE REACTIONS?

By ROBERT E. WILSON, M. I. T., '16, Ph.B., University of Wooster (Ohio)

"BUT you must watch out or you'll be a crass materialist before you graduate." Such was the remark made by a recent graduate of Technology to some students who were planning to enter the Institute.

A single semester's observation is, of course, not a sufficient basis for judging the truth of this, his sole criticism of the Institute. However, I do feel that the danger he mentioned is a real one; not primarily because of any such spirit in the school itself, but because of the very nature of applied science. In the study of *pure* science the student solves one mystery only to be confronted by another, and deeper one, until in despair he is forced to ask himself, "What lies beyond?" But practically every one of our courses of study in engineering work tends to simplify, to reduce to rule and formula, some complicated machine, process, or substance. What has been to us a incomprehensible maze of machinery becomes resolved into its component parts—so many links, cams, and gears each acting in a definite and easily understood manner. The essential mystery of electricity is lost sight of as we learn the perfectly definite laws of its action and rules for its use. The most complex changes in nature, even our own life processes, are reduced to simple reactions between some eighty elements and their compounds. And these are but a few of many examples.

Small wonder, then, that we come to feel that everything is so reducible to its lowest terms of so much matter obeying certain physical laws; that nothing is really incomprehensible; that every seeming mystery is such only because science has not fully investigated it; and so we attempt half unconsciously to explain every fact of our life in terms of matter and physical force—to reduce it all to rule and formula—and ere we realize it, we are indeed "crass materialists." We have come to believe that we are but creatures of flesh and blood, brain and bone,—composed of a dozen chemical elements—and nothing more; that our thoughts and beliefs, our hopes and fears, indeed, all the facts of our consciousness, are but definite reactions, proceeding according to law, and hence that they need no unscientific assumptions of immaterial agencies, such as "mind," "soul," or "spirit," to explain them fully. We feel that our human nature has come, by heredity, from nature itself, and once obtained, is further formed by force of circumstances and education; that all that we can do is react, just as any animal, or plant, or even stone, does in its measure react, to the influences which act upon us; and that such action and reaction, taken together, yield the whole series of occurrences which constitute our lives.

Moreover, carried to its logical conclusion this theory also involves the sacrifice of all belief in our ability to make a real choice between right and wrong. Our course of action is determined according as our hereditary and acquired impulses toward the right are stronger or weaker than our hered-

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itary and acquired impulses toward the wrong. If we decide for the right, it is not to our credit: our external impulses have made any other decision *impossible*. Our sense of moral obligation, our belief in our freedom to choose, our hesitation, our seeming vacillation from one course to another, —all these must be mere figments of our imagination. Our relations and obligations to our fellow men seem vague, and our course of action in such relationships is determined largely by half-repressed instincts and impulses.

The theologian and the philosopher, to be sure, both point out a multitude of objections to such a mode of thought, and for many their arguments are sufficient and conclusive. But for others of us such considerations have but little weight, for our mode of thinking is fundamentally a scientific one. It is my purpose, then, to point out one or two scientific *facts* which seem to me to refute, even from a purely scientific standpoint, this pseudo-scientific materialism.

In the first place we must recognize that while those things which we believe need not necessarily be true, nevertheless, the fact that we *do* believe them must stand as such. We have, for instance, the *fact* of the inherent belief in the heart of every man that he is *not* bound by unchangeable laws to one fixed course of action. The living, throbbing experience of the moral man,—remorse and retribution, approbation and reward,—all the grief and humiliation of his life,—all of its joy and exaltation,—implies a deep and ineradicable conviction that his destiny, if partly shaped by outside forces, is nevertheless, in its grand outlines, *in his own hands*, to make or mar it as he will. All the passion of his moral experience gathers itself up in the one supreme conviction of his infinite and eternal superiority to nature: nature is bound to uniformity—he is free from such bondage.

If these convictions, scientist, are false, as you claim, whence did they originate? Did the Creator, who typifies Truth, implant falsehoods as the very cornerstones of man's mental life? You deny the Creator? Very well; then how *did* these beliefs originate? What experience of prehistoric man can have been responsible for their formation, unless they be true? Or suppose they had their origin in some peculiar aberration in the mind of some individual: why do they still persist in the mind of every individual? Transmitted by heredity, you say. But does not your own principle of evolution teach you, as a fundamental fact, that during the process of transmission by heredity, useless things are always eliminated, and never invigorated? Yet take our sense of moral obligation: if that be not true, it is wholly useless, and yet instead of becoming weaker from age to age, it has ever grown stronger. Materialism, then, cannot even explain the existence of these inherent convictions of ours, unless they be true; but if they be true, materialism must be false!

Nor is that all. If this materialistic theory be true, our whole lives becom meaningless and irrational, and our deepest, most fundamental convictions must be false,—mere fictions of a fanatic imagination. But after all, are not these unproved and unprovable convictions the surest things we have? Science takes a score of such convictions as the very foundation of its own structure. "A straight line is the shortest distance between two points," "the whole is greater than any of its parts," and a dozen like them are just

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as unprovable as our great moral convictions; yet they are made the basis of that most exact science of mathematics. Why should they be taken, and not their opposite? Simply because a system of mathematics so constructed, however consistent within itself, would be considered irrational in that it would violate these unprovable convictions of ours. Have we not the right, then, from a purely *scientific* standpoint, to demand that any theorizer upon the constitution of the mind of man give due consideration to the universal convictions of man with regard to his own nature?

Still another fact must be explained by our scientist: whence, according to his theory, comes man's moral nature—that strange, unreasoning power within him which now declares that *this* is right, and wholly right; that *that* is wrong, forever wrong? The scientist is ready with his answer that this, too, has evolved, according to natural processes, from nature itself. Does this explanation accord with the experience of us who have lived in this world of nature? Evolution does, indeed, provide for the survival of the fittest, but not of the morally best. If the survival of the fittest alone must account for moral progress, should we not expect to find that progress uniformly toward the sterner, and away from the gentler virtues; toward immorality, and away from chastity? Yet the opposite is true. Indeed, has not each of us learned by his own experiences that natural forces are not conducive to any form of morality? that the whole tendency of the natural man within us, and the natural forces without us, is to nullify, to destroy our moral convictions, and not to build them up? that the only force which enables us to maintain our moral standards is something *from within*, higher than nature, transcending natural forces, which struggles against those forces and overcomes them? Indeed, do we not recognize that man as best, in a moral sense, who has most completely conquered his natural tendencies? As Huxley, himself an evolutionist, has said, it is only as man, the microcosm, *pits himself against* nature, the macrocosm, that morality can survive.

Where, then, is the justification for regarding morality as having evolved, by natural processes, from nature itself? Would it not be more rational—aye, more *scientific*—to attribute our moral nature to some higher power working in us, to some divine spark—call it soul, spirit, or what you will,—which gives us the ability, the inspiration, not to follow blindly, like animals, our natural tendencies, not to conform to the forces of nature, but to resist them, to overcome them, and by that very overcoming to achieve those higher and higher planes of morality which mark our human approach to the perfection of God Himself?

In closing I can do no better than quote the words of Frank Parker Stockbridge:

"So that's the answer, eh? We're only lumps
Of ordinary chemicals—some salts,
Acids, and gases, accidentally grouped
In cell formation? There creation halts,
And what comes next is just what comes
When you put this, and that, and t'other bit
Of inorganic matter in your tube,
And watch the mixture swirl, and seethe, and spit,
Till all its atoms find affinities?

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"That's all, you say?. Then life, and love, and hate,
Courage, and hope, and anguish, and despair,
The will to strive, the pride of duty done,
The fear of shame that drives the coward to dare
The death he dreads—all these, you say, are one
With your reactions done in Jena glass?

"O shrewd philosophers!—Your simple plan
To shift the whole responsibility
For all we are, and all we hope to be—
How easy! 'Here's a compound we call man
And here's one called a rock, and here's a cliff.
The rock rolls off the cliff and kills the man.
But can you blame the rock? Nor can you if
The *man* obeys the natural laws that pull
All of us, always, down and ever down,
For if we sink—"reactions"—that absolves,
And if we rise—"reactions"—nothing more.'

* * * *

"Pardon me, gentlemen, but—*it's a lie*—
Reactions, eh? Well, what's your formula
For one particular kind? I won't insist
For proof of every theorem in the list,
But only one: what chemicals combine
With CO_2 and H_2SO_4
To cause such things as happened yesterday,—
To send a very gallant gentleman
Into antarctic night, to perish there
Alone; not driven, nor shamed, nor cheered to die
But fighting, as mankind has always fought
His baser self, and conquering, as mankind
Down the long ages, has always conquered self?

"What are *your* tests to prove a man's a man?
Which of *your* compounds ever lightly threw
Its life away, as men have always done,
Spurred not by lust, nor greed, nor hope of gain,
But casting all aside on the bare chance
That it might somehow serve the Greater Good?

"*There's* a reaction—what's *its* formula
Produce *that* in your test tubes, if you can!"

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PATRIOTISM AND MILITARISM VERSUS JINGOISM

By LANSING McVICKAR, M. I. T., '18

IN an essay which appeared in the February issue of the Monthly, sentiments were expressed which seem to me to be of such a dangerous nature that, although unsponsored by the editors themselves, they ought not to be left without formal contradiction. The article, entitled "Militarism, Patriotism and Jingoism," pointed toward the conclusion that we should be first humans, then Americans, that we should first recognize as brothers and co-workers all those of different race and nationality, work with them—not against them—for the betterment of the world. This, of course, would eliminate war and the evils connected with it. We would all live in a harmony of civilization, each race helping the other, each man his neighbor; indeed, "the soldier would be an anachronism." This no doubt would be a perfect state of affairs. But it is centuries—nay, eons—ahead of the present time. The soldier may sometime be an anachronism; we all hope so with all our hearts. He is not yet so; he is an essential factor in the life of nations. Mind, I do not say war is good. It is to be avoided at greatest cost. I do say that we could not do without the soldier any more than we could do without the policeman. In this Utopia of disarmament so lauded by the other nationalities, creeds and races were to be disregarded. We must find "humanism" a substitute for "patriotism," and argument a substitute for arms. Even argument, however, would be o little value for we would all have the other man's interests so dearly at heart that there would be small cause for argument. Unfortunately for this undeniably excellent plan, the world has not yet attained that pitch of social altruism wherein every man will think for his neighbor before thinking for himself. Human nature is not yet perfect; the world's development must be gradual. For the Rome that is built in a minute is as unstable as it is unfruitful.

It may be seen by glancing at the history of the world that we have tended from the beginning to a combining together of individuals, until in some far off day, the world, even the universe, may be united in the same way. It has been done along definitely traceable lines; at first, the lone hunter was the unit. He was responsible only to himself, seeing only after the welfare of his immediate family. Then came the family, the clan, the tribe, the petty kingdom, and finally the federation such as our own and those of the Great Powers. Up to this time the growth has been fostered by the fact that one clan, tribe, or kingdom has taken to itself the weaker ones which fall to its conquest, or to the more peaceful methods of aggrandizement, voluntary union, and purchase. The union of humanity will come, as have all other advances, not by the combination of numberless petty states, but by the gradual enlargement of a few such empires as Germany and the United Kingdom. The world is on the road to humanism; it will

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not be ready for it for a long time to come. This growth of our own countries, this pride of birth, this patriotism so scorned, is the means to the ultimate end. By destroying patriotism you destroy the very foundations of world peace. This "cardinal vice" is the very keystone of advancement. Surely, the fact is comprehensible that to benefit one's own country is to benefit the world. For it is through, and only through the advancement of the individual countries that final and universal union may be obtained.

This accounts, then, for Patriotism. In rivalry lies advancement; the progress of individual countries raises the standard of world civilization, for the ideal state is not each man for himself but each man for every other man, and each man for his country is a long step toward this goal. Let us not whimper, then, about the uselessness of war; let us not substitute cowardice, in the name of humanism, for patriotism; but let us, though avoiding war at greatest cost, take up the standard when it is forced upon us and fight *with* patriotism *for* peace.

What is patriotism? it might be asked. Is it merely to fight, or is it to obtain prosperity at the expense of other lands? No, it is neither of these. It is the passion for the progress and development of home. Since the beginning of the world man has protected and advanced his native land; when he ceases to do so he will be at a lower—not higher—stage of civilization than in the most primitive of ages. Patriotism is but an indispensable aid to mankind.

It is a most commendable desire for the prosperity of home that leads men to say "See America First!" and to advise the spending of American money in America and such "attendant yelps." This, of course, does not mean that it is well to be blind to the virtues of things not American —narrowness does not spell advance. A realization of our own faults, and an insuperable determination to see ourselves at the head by the mastery of those faults, is the right patriotism. Indeed, any man who cannot see the virtues and good points in not only the Chinese, but in whatever nationality with which he is associated, is, if not "hopeless in his barbarism," certainly exceedingly narrowed. But any man who, while still claiming allegiance to the American flag and the protection of the American government, should do something which would advance the other country at the expense of his own on the ground of "humanism," cannot even be dignified by the term "barbarian."

We find, then, that patriotism is right and that the right kind of patriotism is to seek for the peaceful prosperity of one's own country. Why, then, the soldier? Why would it not follow logically in the steps of progress to do away with the soldier, the author enticingly suggests. Firstly, lastly, and entirely, because it is impracticable, just as the socialistic theory of an equal distribution of land and wealth is impracticable. Just as, if an equal division of wealth were made, ten minutes would not elapse before one man had someone else's gold, there would be some one nation which would cause endless loss of life by taking advantage of the peaceful attitude of her sisters, until the whole must begin over. Peace will finally come not by the laying down, but by the uniting of arms, a step too advanced and permanent to be taken as yet.

If you were standing on a street corner and someone coming up deliberately kicked you, although it

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might savor of an unusually high state of civilization merely to remonstrate with the man, it certainly would not be a very effective way of stopping him from doing it a second time. And even at the present day it might be construed —we could almost say, with justice— as approximating cowardice. We need the soldier as we need our fists. It does not make a peaceful man less peaceful to sleep with a revolver under his pillow; it merely makes him respected by his neighbors. But it is another thing for him to walk about swinging it in his hand—that is jingoism. There is a great distinction, however, between patriotism with a necessary amount of militarism and jingoism, as the word is now used. Away with jingoism;—indeed, away with war! But let us keep the soldier, as the policeman, to enforce it. It is much more effective to do as the author suggests,—say, "Be peaceful now, damn you, or I'll knock your head off!" than to argue with a raging bull.

As for the stupidity of soldiers and the claim that they are not "men," as well talk of the stupidity of policemen and argue that a subordinate in any profession is not a *man*, because he does what he is told with courage and promptitude. The soldier is coddled! The ludicrousness of this statement confutes it to its face. The only light which can possibly be thrown upon it is the fact the author has in mind, the necessary and beneficial discipline which the soldier undergoes, when he speaks of coddling. But for all he may cite the DuPont powder factory and other cases I maintain that no successful work has ever been contemplated in which every man was permitted to think for himself or to depend on his own resourcefulness. Discipline is an essential factor in all civil as well as military operations.

Yet, "the soldier, useless in times of peace, becomes when the least excuse for war arises, a real menace to the nation by forming the hot-bed of jingoism and poltroonery." As well,—the policeman, useless when no crimes are being committed, makes arrests at the least excuse; or the revolver carried by a *sane* and *peaceful* citizen, useless when he is not attacked, becomes a real menace by going off easily; or some similar statement. The fact seems to be lost, however, that when necessity—to be as far removed as possible, it goes without saying—*does* come, the soldier, the policeman, and the revolver are all indispensable. The "trained civil force, free from all trace of military tradition"—which, by the way, could in no way resemble a police force if it were without discipline—would be as inefficient as it is idealistic.

Now, last of all, let me mention the principles of my title in connection with the disturbances in Mexico; for there is, indeed, a great question as to the justification of war. Our action in Mexico, its treatment by the administration, may or may not have been right, but one thing is certainly true; it is that if Americans are being mistreated in any part of the world it is the duty of the American government to give them protection. It matters not whether the outrages have occurred in Mexico, Spain, or Madagascar; it matters not how foolish they may have been to go there. In any case the important fact is that Americans have been mistreated. This overcomes all things; it is the duty of every other American whether he comes from Rhode Island or Oregon to see that the offenders are punished, be

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they Mexicans or otherwise. Although I should not hope to see the slightest interest bestowed on a foolhardy boy injured by a crocodile, when not one, nor two, nor three, but when repeated acts of violence have been inflicted on our citizens by a definite nation or people in no matter what part of the world, then I want the American people as represented by its government to take some measures for their safety. For the fact still remains, granted that they were foolhardy, that they were American citizens injured by foreigners.

And by that same principle of patriotism, the desire for the advancement of one's own country, we must advance and uphold her honor—easier though it be to go on "being happy and having children." In order to do this it is necessary to prevent a thing possible in every coherent sense of the word, an insult to the flag. Done insignificantly by insignificant people, it is too small a thing to make trouble about; but, done flagrantly and on a large scale with the nations of the world as audience, it must be stopped quickly and effectively, if necessary by force of arms.

To conclude then, let us have patriotism for our homes, our race, and the ultimate peace of the world. Let us have a moderate amount of militarism as patriotism's weapon of defence and the protection and advance of our state. With it, let us have the old standby, drill here at the Institute, in order that we may know how to defend our country if she needs us. But—and here is the whole gist of my argument—let us beware of inaugurating jingoism into our creed, let us not walk round showing our fangs, barking and snapping at all;—but let us see keenly the difference between patriotism and jingoism and beware of all those who confuse them to either extreme. Lastly, let us steer far away from a cowardly substitution wherein we must lose one of the most precious qualities we possess.

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TWENTY YEARS STUDYING THE SUN

By CHARLES GREELEY ABBOT, M. I. T., '94

Director of the Astrophysical Observatory of the Smithsonian Institution

DURING the first ten years of my connection with the Smithsonian Institution I was closely associated with its third Secretary, Dr. S. P. Langley, who was founder and director of the Astrophysical Observatory until his death in February, 1906. He was a remarkable man, and not only so for his epoch-making advances in two fields of science, namely, solar physics and aerodynamics, but remarkable in his appearance, words, and acts. His associates expected him to do the unexpected.

The enclosure of the Astrophysical Observatory in the Smithsonian Park was not very large at the time I went to Washington in 1895, but for several years there were frequent enlargements by Dr. Langley's orders, so that it came to be a kind of joke to ask at the Institution if we had not better put the fence on wheels. One winter's day it occurred to Dr. Langley that some scientific men attending a meeting in Washington might visit us at the Observatory the next day. He instantly summoned more than twenty painters and had that long high fence painted within and without between three o'clock and dark of that short afternoon. At another time it seemed to him that it would be better if a certain hedge near the Institution should be prolonged about fifty feet. As the hedge was of several years' growth there would have been, for an ordinary man, a period of waiting till the new part sensibly caught up with the old. Not so for him, for he had the little shrubs planted so thick that the new part was of equal density to the old, right off.

In telling a story, Dr. Langley never waited for a possible anti-climax after the point was reached. One autumn day after his return from his usual summer visit to Europe, he came over to see what we had done in his absence, and especially to see a new laboratory building which had been built. After finishing all he had to say and see about the work he pointed to the door, which had been painted green outside, and said, "Mr. Abbot, your door reminds me of a little saying I heard when a child: 'Neat, not gaudy, as the Devil said when he painted his tail pea-green.'" With the last word the Secretary rushed away without looking back.

Langley's great work on the sun was done with the bolometer, a highly sensitive electrical thermometer which he invented about 1880 while Director of the Allegheny Observatory. The bolometer consists of two blackened metal strips forming two adjacent arms of a Wheatstone's Bridge. One strip is hidden from the rays to be measured, the other exposed to them. Thus one strip is warmed with respect to the other, a change of relative electrical resistance occurs, and the unbalancement of the bridge is indicated by a sensitive galvanometer.

At Washington, Langley introduced automatic recording by photography, a spot of light being reflected from a galvanic mirror on a moving plate. In solar

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work a spectrum of the sun ray is caused to fall upon the exposed bolometer strip, and the same clockwork which moves the recording plate at the galvanometer also moves the spectrum slowly past the bolometer. Thus is produced a "bolograph," as Langley named it, similar to the accompanying figure which depicts the relative intensity of the rays of the solar spectrum. On such a curve the dark Fraunhofer lines, which are seen in the solar spectrum, appear as nicks or depressions, because they are places of diminished intensity of radiation.

The bolometer as we usually employ it

is so sensitive that one-millionth of a degree of rise in temperature of the exposed strip produces 0.1 mm. deflection on the galvanometer scale. In the years prior to 1900 we were engaged in making improvements of bolometric apparatus, and in producing by its aid a map of the so-called infra-red spectrum of the sun. We published in Volume I of the Annals of the Astrophysical Observatory the wave-lengths and intensities of about seven hundred absorption lines and bands as discovered by bolometric work beyond red end of the visible spectrum, and extending, as Langley put it, "to ten times the wave-length known to Newton."

In the years 1900, 1901, and 1908 we gave much attention to total solar eclipse work. Expeditions were sent to North Carolina, to Sumatra, and to Flint Island in the South Pacific. A novel feature of our observations was the use of the bolometer to measure the head received from the solar corona. In this we were successful and obtained in 1908 not only the relative intensities of the coronal radiations at various distances from the sun, but by the aid of the absorbing screens were able to compare the quality of the coronal radiation with that of the sun and the moon, and thus to show that the coronal light is probably not due mainly to the incandescence

of its own particles, but to so-called "luminescent" action.

In 1902 we began a research to determine the total intensity of the solar radiation outside the earth's atmosphere at a mean solar distance, or as it is called, "the solar constant of radiation." If the observer could stand upon the moon a great difficulty would be gone, for the atmosphere of the earth affects the rays of the sun in several ways. First there is the scattering by the molecules and finest dust particles, which, as Lord Rayleigh has shown, is proportional inversely to the fourth power of the wave-length. Second there is the diffuse reflection by the larger dust particles and haze agglomerations, which varies much less rapidly with wave-length. Third is

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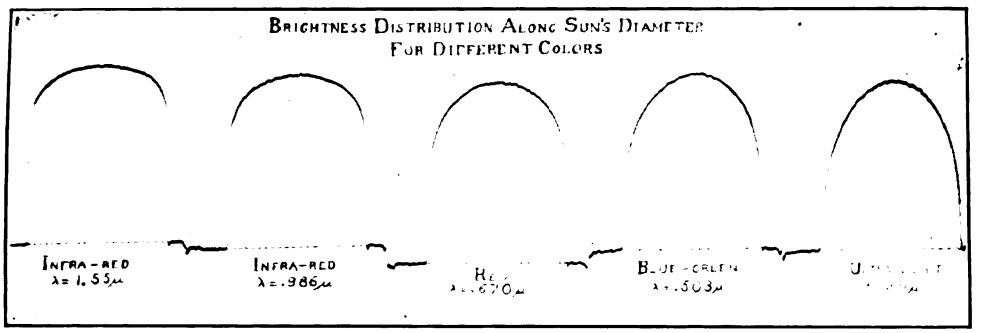
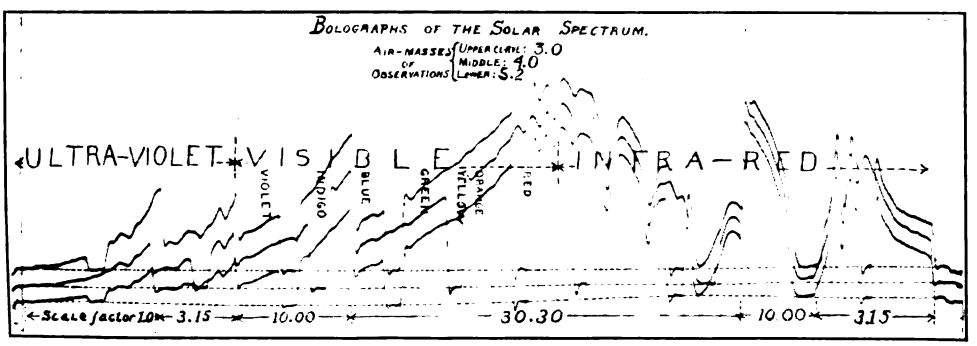


the absorption by the gases and vapors of the air which is restricted to narrow regions of the spectrum, but which is exceedingly strong in these regions. Very strong and wide bands of water vapor exist in the infra-red spectrum. It is necessary to study these various losses by spectrum analysis with the bolometer in order to determine what they amount to in total.

Langley had gone over the ground of this research in his classical expedition to Mount Whitney in 1881, and had laid down the method substantially as now practiced. But the improvement of the bolometer and especially its automatic registration gave a great advantage to the later observers. It was necessary, however, to devise and test at great length apparatus for measuring the total heating effect of the sun in calories. After several years of experimenting on this line two forms of standard pyrheliometer and one secondary pyrheliometer were perfected at the Astrophysical Observatory, and through them the standard scale of radiation measurement has been diffused to many parts of the world. About twenty-five standardized silver disk pyrheliometers have been furnished by the Smithsonian Institution to foreign observers.

Early in our "solar constant" campaign it was indicated that the sun was not really constant, but variable within limits of about 10 per cent in its output of radiation. As the atmosphere at Washington is unsuitable for work day after day, such as the investigation of the sun's variability demands, a branch observatory station has been founded on Mount Wilson, California, near the solar observatory of the Carnegie Institution. Great aid has been given us there by Director Hale and his staff. In an effort to test more thoroughly the accuracy of our method of estimating the atmospheric transparency, expeditions



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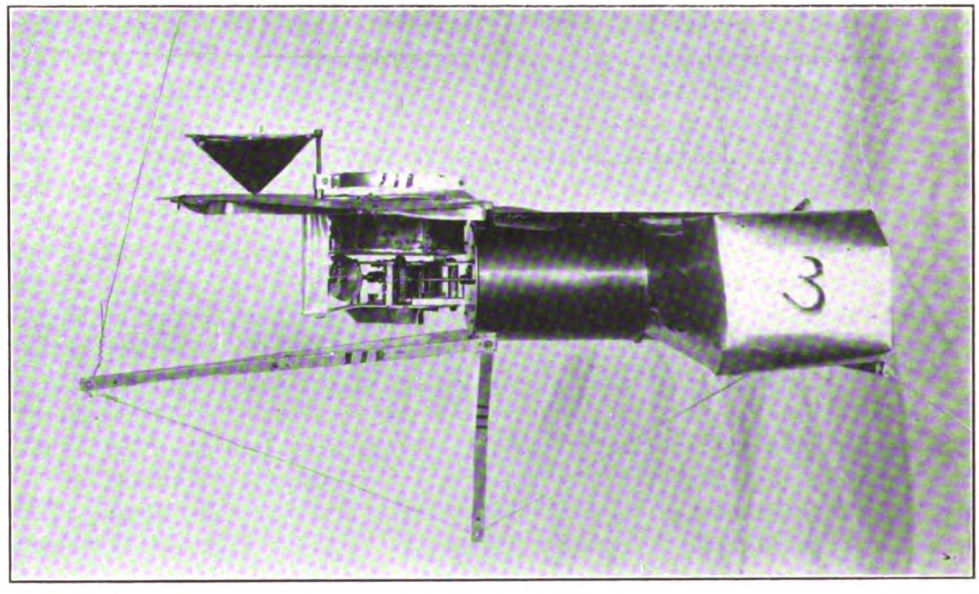
occupied the summit of Mount Whitney also in 1908, 1909, and 1910. This mountain in California is 14,502 feet high, and in Langley's famous expedition of 1881 bolometer observations were made at about 2,000 feet below the summit on its west side. The solar constant results obtained at Mount Whitney in 1909 and 1910 were entirely confirmatory of the results obtained simultaneously at Mount Wilson, and greatly strengthened the belief in the soundness of our method.

On Mount Wilson the solar constant of radiation was determined many times in every year from 1905 to 1914 excepting 1907. The values obtained show on their face a short irregular periodicity of solar radiation ranging often through five per cent or more in a week or ten days.

In order to confirm this variability thoroughly as a true solar phenomenon and not due to some defect of the observations, expeditions occupied a station in North Africa in 1911 and 1912.



Recently Dr. L. V. King of Montreal and my colleague, Mr. Fowle, have independently calculated from Mount Wilson and Mount Whitney results on the transparency of the air, the number of molecules present in a cubic centimeter of air at standard temperature and pressure. They find respectively 2.77 and 2.70 billion-billions. These results are in very close agreement with determinations by quite other methods, and strongly confirm the theory used in our determinations of atmospheric transparency.

Solar constant values obtained on identical days at both Mount Wilson, California, and Bassour, Algeria, agreed in showing the supposed variability of the sun. Values found at one station were duplicated at the other within an average deviation of one per cent, although a range of values from 1.82 to 2.00 calories occurred during the period of observation. Thus independent observations, at stations separated by one-third the circumference of the earth, united in showing an irregular variability of the sun over a range sometimes reaching

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ten per cent, and frequently as great as five per cent.

Not only is the sun variable from day to day, but its output of radiation varies from year to year in connection with the march of sunspottedness. Our measurements at Mount Wilson indicate that there is about three per cent greater intensity of solar radiation in the years of sun-spot maximum, 1905 to 1908, than in the years of sun-spot minimum, 1910 to 1913. A close correlation was found to exist between the mean monthly sunspot numbers and the mean monthly solar constant values.

Very recently we have confirmed the variability of the sun's radiation by measurement of the distribution of light over the sun's disk. The sun is brighter at the center than at its edges. This contrast of brightness between the center and edge is greater for blue light than for red light, and indeed decreases regularly with increasing wave-length of the light. Our bolometric observations show that the contrast for a given wavelength is not constant from day to day or from year to year, but varies in close correlation to the variation of the sun's total radiation. The contrast is greater in years of sun-spot maximum and, as said above, the solar radiation is also more intense at that time. But as regards the changes of contrast from day to day in a single, the *greater contrasts* are found to attend the *less radiation.* Thus the interest in the subject is enhanced, for there appear to be two kinds of solar variation, one attending spottedness, the other going on at all times, and these two kinds of variation produce opposite effects on the contrast of brightness between the center and edge of the sun.

When we began our measurements of the solar constant of radiation, it was the general belief that its value was upwards of three calories per square centimeter per minute. Our observations obtained at different altitudes from sea level to 14,500 feet and at four different stations agree closely in yielding a mean value of 1.93 calories. Within the last two years we have been able to confirm this conclusion by a striking experiment. Special automatic recording pyrheliometers were constructed in the lightest possible manner, and sent up attached in each instance to a pair of free india rubber balloons. At a great height one of the balloons must burst, and then the other comes softly down with the apparatus. In one experiment made at Omaha in July, 1914, our instrument was carried to so great a height that more than nine-tenths of the air was left below. Excellent records of radiation were obtained, and these gave values of the solar radiation which when reduced to mean solar distance slightly exceeded 1.8 calories per square centimeter per minute. As the clouds of dust, appreciable quantities of water vapor, carbon dioxide, and other considerable absorbents and hindrances to the rays are left far below at such altitudes, the close agreement of the result with our value of the solar constant of radiation is very satisfactory.

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THE TEACHING OF THERMODYNAMICS

IV

THE MEAN ENERGETIC CONDITION, TEMPERATURE, WORK-PERFORMANCE, AND THE RADIAL COMPONENT

By PROFESSOR SIDNEY ARMOR REEVE, M. E.

(1) *The Mass-Factor* MM, or ΣMM, has already been discussed sufficiently as to detail. It is the quantitative feature of mechanical and thermal energy corresponding, I believe, with the quantitative factor plainly running through all forms of energy, and which I have styled the "factor of extent" in my text-books. The universality of some such a factor, and of the dual nature of every form of energy, has long been recognized. Sir William Ramsay, in his address before the International Congress of Arts and Sciences at St. Louis, in 1904, said:

"I have already, in an address to the German Association at Cassel, given an outline of the grand problem which awaits solution. It can be stated shortly, then: While the factors of kinetic and gravitational energy, velocity, and momentum, on the one hand, and force and distance on the other, are simply related to each other, the capacity-factors of other sorts of energy—surface, in the case of surface-energy; volume, in the case of volume-energy; entropy, for heat; electric capacity, when electric charges are being conveyed by means of ions; atomic weight, when chemical energy is being gained or lost—all these are simply connected with the fundamental chemical capacity, atomic weight, or mass. The periodic arrangement is an attempt to bring the two sets of capacity-factors into a simple relation to each other; and while the attempt is in so far a success, inasmuch as it is evident that some law is indicted, the divergences are such as to show that finality has not been attained. The central problem in inorganic chemistry is to answer the question, Why this incomplete concordance?"

But is it a fact, as Sir William states, that the capacity-factor in mechanical energy, force, etc., is so simply related? If this fact of a variable *mass-pairing* factor, within each constant aggregate mass, be kept in mind, is the concordance so incomplete?

Whatever may be the final answer in regard to identity between all these diverse forms of energy and their capacity-factors, this much is beyond question already: That in so far as we base our ideas of heat upon a mechanical foundation, and in so far as we hold (as we have concerning heat and work) that mutual transformability proves identity in nature between other forms of energy and work, just so far must our concept of the capacity-factor follow the mathematical and physical features just described in relation to ΣMM, and not the simpler idea of a single homogeneous mass-factor M held forth in the standard atomic theory or the usual college course in Applied Mechanics.

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No single mass can embody energy, and the mass-factor of all forms of energy, per unit of aggregate mass, must be regarded as a variable.

(2) *The Mean Energetic Distance D* gives, of course, the measure of the mean *volume* of the mass-pair, or, for a system of mass-pairs like a molecule, its mean occupation of geometric space. Before proceeding further with discussion of this feature it is necessary to call attention also to the

(3) *Eccentricity of Orbit e,* which is most plainly measurable at the position of mean energy, B, Fig. 1. The relative velocity U of the pair at this point—and it must be remembered that any and every fund of internal energy is reducible to, and is the mathematical and physical equivalent of, such a mean energetic position—is always composed of two components, a tangential u and a radial w. The ratio of these two components (radial to tangential) is the cotangent of the angle ι_α and is also the eccentricity of orbit e. Upon this ratio or eccentricity the physical characteristics of the energy-pair depend to a marked degree.

First, it will gradually be realized, but only upon study, that, viewing the pair from without, as a unit, as we do a molecule or an atom, or an electron, etc., the *tangential* component u belongs wholly to the pair itself and is not to be perceived directly by any outside system, nor by any means which does not distinguish between the two whirling masses as separate independent units. The *radial* component w, on the other hand, is the component alone perceptible by external systems.

Thus, if a pair having only tangential motion be approached by a third single body of the same scale of magnitude, that third body will perceive each of the first two separately, and will form with each motion-pair in which the motion is not, and cannot be, wholly tangential. To the degree to which it is not, force and energy may be perceived and interchanged. The final word as to what occurs in such a case must await the mathematical solution of the "problem of three bodies."

But if such a pair having only tangential motion be approached by another and similar *pair* of the same scale of magnitude, then each pair will appear to the other as a unit. The interaction at a distance will be as if each pair were a single homogeneous mass. As the two pairs approach within distances comparable with their own orbit-diameters their orbits will be distorted; but this will have no effect upon the preceding statement.

Only when the propinquity becomes so marked that the orbits tend to infringe one upon the other will there be any force of repulsion between the two. Until the orbits actually interfere, mutual attraction must be the fact; but when they do interfere this attraction is altered to mutual repulsion.

The suddenness and force with which this change takes place, or the "hardness" of the mass-pair, so to speak, can be stated by equating Equations 1 and 2 (and stating the symbols for the mean energetic position), giving, as the force of radial repulsion,

$$F_r = \frac{c}{D} = \frac{u^2}{M + M} \quad (8)$$

If the aggregate mass of the pair be taken as constant, then D and u^2 are inversely proportional. The force, as well as the suddenness, of the mutual repulsion between two such pairs will be

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inversely proportional to D, the mean energetic diameter, or volume, of each pair.

But this is quite in accord with one of the basic characteristics of gaseous matter, if not of other forms, viz.: That its pressure or "hardness" is proportional to its density, or inversely proportional to its volume.

SUMMARY. In short, if we are to assign to heat any mechanical explanation whatever, it must be in terms of the Newtonian mechanics, and the Newtonian mechanics is always a function of at least *two* mass-portions, with elasticity solely a function of the space between the two. So far as mutual attraction and repulsion between the thermal molecules is concerned, one need assign to each molecule only a single mass, so long as thermal equilibrium—which is the equivalent of no collision between the molecules—is the case. Motion of approach will be altered into repulsion and retreat with perfect elasticity, and with the angle of reflection equal to the angle of incidence. But the motion of both approach and retreat will be along a conic-section orbit (undoubtedly a hyperbola for gases) instead of along a straight line.

But as soon as thermal equilibrium is upset, by the advent of impact, friction, thermal conduction, electrical resistance, etc., the assumption of one mass-portion per molecule no longer suffices to explain heat mechanically. And since we have reason to believe, from other sources of evidence, that each molecule is indeed a most complex system of mass-portions, the single-mass hypothesis need no longer be adhered to. The peculiar thing about the present aspect of the text-books is the inconsistency between the wide acceptance of the molecule as an intricate system of mass-portions, on the one hand, and the continued reliance upon the hypothesis of perfect elasticity of molecular matter, on the other, which becomes as unnecessary as it is absurd as soon as the molecule ceases to be imagined as something like a billiard-ball.

In spite of the fact that our mathematics of free bodies does not permit us to treat exactly an intricate system, representing a molecule, yet this is not necessary. It develops that a single mass-pair embodies all the thermal characteristics of the gaseous or liquid molecule, in elementary form, and suffices as a foundation for our thermal concepts. All that is necessary is to imagine that the relative division of the total mass present between the two reacting portions may vary, from time to time—as would naturally occur in an intricate system; or that a number of mass-pairs will evince characteristics similar to a single pair, which is doing no violence whatever to reason and experience.

In a molecule consisting of such a system of mass-pairs, therefore, its *volume* is represented by the *mean energetic distance* D, and its *hardness,* or the force with which it will resist passively any external force tending to compress it, will be inversely proportional with D, or directly proportional with u^2. This, as already remarked, is not only in direct agreement with our experience with gaseous molecules, but it is roughly true of all forms of matter, if we make allowance for the disguise of purely thermal phenomena put on by crystalline structures and forces. Hardness generally goes with density. The many exceptions to this rule are not enough to deny its force. Its truth in relation to solids versus liquids and gases is almost unbroken. For each exception among the solids, where, as with glass and lead, the denser element is the softer, a dozen op-

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posite instances may be found. And among the liquids mercury is almost the only one which is more dense than the familiar inorganic non-cellular solids. In the case of liquids versus gases hardly a single exception can be found to the rule of greater density on the part of the liquids.

TEMPERATURE, WORK-PERFORMANCE, AND THE RADIAL COMPONENT. Turning now to the feature of active vapor-pressure, and the distinction between the gases or liquids, which possess this feature to a marked degree, and the solids, in which it is a minor incident, this brings us to a consideration of the *radial* component of motion at the mean energetic position, and its ratio to the tangential component, which ratio is called the *eccentricity* of the pair's orbit. If this ratio be less than unity, the orbit is *elliptical*, and the two mass-portions forming the pair (or molecule) tend to stay in permanent combination, until broken apart by some external force. But if this ratio be greater than unity, then the orbit is *hyperbolic* in nature. After a single periastron revolution, or swing-partners movement, such a pair will tend to separate indefinitely, unless forced back into continued propinquity by some external pressure.

This, plainly, is the prime characteristic of gases. They tend to expand indefinitely, until arrested by some external force.

These facts lead directly to the exact mechanical concept of *temperature*, which has long been known as the linear kinetic energy of the molecules, or pure *work*. But hitherto these molecules have been habitually pictured as flying in straight lines, from collision to collision. Now, however, it is noted that straight-line motion is impossible in nature, and that collision between molecules is inconceivable as a feature of thermal equilibrium. The truth is that the molecular orbits in gases are all *hyperbolic*, asymptotic to but never coincident with straight lines. Reflection of energy at each molecular encounter occurs by peri-revolution, instead of by collision. Temperature is the kinetic energy inherent in *only the radial component* of the orbit.

This radial component will therefore increase with temperature, but it may increase quite independently of the tangential component. With it must increase the active, expansive pressure, which is the integrated radial *momentum*, following Boyle's law. With these also must increase the eccentricity of orbit (the tangential component remaining constant), the co-tangent of the orbit's angle with the radius vector common to each pair of masses at the mean energetic position, and the approach of the hyperbola to a straight line. But since only an infinite cotangent can reduce this angle to zero, only an infinite temperature, attained by an infinite accession of energy and evincing an infinite expansive pressure, —making of the stuff a "perfect" gas, with zero viscosity—can ever reduce the hyperbolic orbit of Newtonian mechanics to the conventional rectilinear orbit of the orthodox atomic theory of Applied Mechanics.

Work Can be Performed only Radially. This identity of temperature with only the radial component of molecular motion is also quite in accord with all else we know about work-performance. For this last can occur, at the behest of internal energy or heat, *only* when a body expands. Expansion means either an increased volume of molecule, or an increased degree of separative motion along radii be-

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tween molecules, or both. But either or both, when each molecule is represented by a mass-pair, means increased *radial* component of orbital motion, and can have nothing to do with any *tangential* component of molecular motion.

Indeed, a glance at the mechanics of a mass-pair considered as a unit makes it evident that no external compressive force—nor any deficit of such, permitting adiabatic expansion—can possibly affect the *tangential* component of molecular motion. These forces must act radially only, or normal to the surface bounding the molecule; and a force can produce no effect at right-angles with its direction.

Impact and Friction Can be Performed only Tangentially. What then, in this connection, is the mechanical explanation of entropy? Suppose that some external supply of impact, friction, or thermal conduction upsets the equilibrium between the molecules, so that, where was previously no collision, collision now occurs. This, as already noted, must mean merely that two or more mass-pairs or systems, each representing a molecule, are forced into such intimate approach that what was previously regarded as a unitary mass-portion becomes broken. The energy brought in from without is absorbed in effecting fracture against cohesion. In engineering, when impact or friction occurs, some of these fragments may be of visible size, some are microscopic and are called "wear," and some are of molecular magnitude only; and the development of these last, is called in thermodynamic language, an "increase in entropy." This process of molecular fracture must proceed, it was noted, until the fragments are so small that molecular "collision" and further fracture no longer occur. The orbits are again permanent, in stable equilibrium; but there are now a larger number of mass-parts and orbits acting thermally.

It is now plain that this process can affect only the *tangential* component of molecular motion. First, only a decrease in tangential motion on the part of the external systems can introduce impact or friction, where none existed before, to upset the internal equilibrium of the body. For if *radial* influences enter from without, whether in form of force or motion, they can appear only as work-performance, in contrast with impact and friction; and they can influence only the radial component, or temperature, by adiabatic compression or expansion. Secondly, this impact or friction can influence only the tangential component of the internal orbits; for what we mean by the terms "impact" and "friction" is energy which is *not* preserved as a radial, or reversible, work-effect. Also, viewing the thing subjectively, it is only an increase in internal tangential components which can reinstate equilibrium by eliminating collision, by getting the mass-portions further apart, by centrifugal force, during periastron, the time of closest approach.

Thus it is obvious that *entropy*, which is the universal characteristic of impact or friction,—or of their thermal equivalents: thermal conduction, electrical resistance, etc.—must be closely a function of the *tangential* components of molecular motion. It is not identical with these components, but it is their inevitable result, or better, their other aspect, viz: Greater disintegration of matter, or greater subdivision of the molecule into more numerous and smaller parts.

So far, then, as thermal features may

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be traced through the three physical states (solid, liquid, and gaseous) without disguise due to the crystalline structure of the first named class, all of the internal characteristics of hot or cold matter find exact parallel in the variables of any Newtonian system of mass, space, and motion. All such features are observed in actuality, as integrations of the *average* energetic state of myriads of molecular systems. Hence all features of the Newtonian representative system must be referred to its Mean Energetic Condition, at *latus rectum*, for illustration or explanation.

In this condition the *volume* of the molecule is represented by the radius vector distance between the parts in orbit. *Temperature* is the kinetic energy involved in the radial component only of the relative motion. *Gaseousness* is the eccentricity of orbit, or ratio of radial to tangential velocity, squared. *Active* or *expansive pressure* is the momentum of the radial motion. *Passively resistant pressure*, or "hardness," or solidity, or viscosity, is the tangential component of orbital motion (squared), or is the inverse of the *latus rectum* or volume. *Entropy* is the number of component particles into which the aggregate mass is divided—necessarily a function of the tangential motion.

Much of this parallel is identical with the orthodox atomic theory of gases, which rests upon the hypotheses of perfect elasticity of each molecule and straight-line paths of molecules from collision to collision. This later development merely adds to that orthodoxy (1) partial penetration and circumrevolution, at each encounter between molecule and molecule, as a substitute for supposing the molecules to be made of matter so different from all known matter as to be perfectly elastic; and (2) the constant presence, in combination with the radial or straight-line path of molecule from collision to collision, of a certain portion of *tangential* motion of circumrevolution also, constituting the solid, viscous, entropic, non-condensible portion (or feature) which is characteristic of all matter.

Now in the Newtonian system it is natural to conceive of all degrees of eccentricity of orbit, or of all proportions of radial to tangential motion, except zero or infinity. For, as to the first, we can imagine no dynamic means for the abstraction of *all* radial motion. The less there is of radial motion the harder it is to abstract it. No external system can abstract it unless itself having less radial motion than the system to be reduced. Conversely, the state of infinite radial motion is equally inconceivable; for the more radial motion a pair possesses the harder it is for any external system to contribute energy radially to it.

But in this is visible an exact parallel with thermal equilibrium in actual matter. Temperatures vary through a great range, in nature. But in the lower field they approach a hard and fast limit—the absolute zero—which they can never be made to reach; while, as they approach it, volumes and pressures no longer maintain proportionality to temperature, but tend to a fairly fixed minimum *before* zero temperature is reached. In this region thermal phenomena consist much more of alterations in entropy than in temperature, while the characteristic physical features are solidity, impact, and friction, in substances in which these are unknown at ordinary temperatures.

(To be continued in next issue)

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EDITORIAL SECTION

The Technology Monthly and Harvard Engineering Journal

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All manuscripts submitted for publication in the TECHNOLOGY MONTHLY AND HARVARD ENGINEERING JOURNAL should be accompanied by the writer's full name and address. Manuscripts not accepted for publication will be returned only if the author so requests. Photographs, drawings, etc., will be returned to the contributor immediately after publication.

Forms close the 28th of the month immediately preceding date of publication. Material specially arranged for may be received up to the fifth day following.

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TEAM WORK

NO argument is needed to convince the average college graduate that student activities are a benefit and that student organizations are to be numbered among the most useful of the character-building phases of student life. But it seems to have taken the faculty of at least one great engineering school some little time to come to the same conclusion.

But it is to be noted that eventually the faculty of any school must realize, at least as well as the students of that school do, that student activities promote team work. It takes a great deal more than faculty indifference to kill an organization of students; it takes very little more than an encouragement on the part of the faculty to perpetuate the same organization.

Cases without number can be cited to show that the student who does no have a part in some student activity when he is at college lacks the power of co-operation when he meets his practical commercia problems. The apparently inherent power to co-operate is born and weaned right back in the student activities at any school. And the greater the energy put on the activities, the greater will be the student's power to "get along" with his business associates and personal friends.

As an action is always followed by its reaction, so that the faculty interest in student affairs has found itself, presented in the most subtle manner, seeking a remedy for that lack of ability prevalent among the graduates professional men to co-operate with outsiders. In order for the faculty of any school to overcome this handicap, it must make a human analysis of all the causes which lie at the bottom of any human trouble.

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HARVARD ENGINEERING SOCIETY OF NEW YORK

ON February 18th, the Society was entertained by the Cornell Society of Civil Engineers, at the Cornell Club, 65 Park Avenue, New York. About twenty-five of the members attended. The subject of "Capital and Labor" was discussed by Professor Jenks, Professor of Political Economy and Politics at Cornell, and a representative of the Board of Business Agents of the Building Trades Union. After the meeting refreshments were served, and an opportunity offered for a better acquaintance among the members of both societies.

A regular meeting of the Society was held Wednesday evening, March 3rd, in Harvard Hall of the Harvard Club. The meeting was held in conjunction with the Harvard Club and we also entertained the members of the new Yale Engineering Association as our guests.

The meeting was given over to a lecture by Mr. Miller Reece Hutchison, E. E., Ph. D., Chief Engineer of the Edison Laboratory, Thomas A. Edison, Inc., and personal representative of Thomas A. Edison, entitled, "Edison and Some of His Inventions." There were seven or eight hundred present. Mr. Richardson, our Vice President, presided at the meeting and dispensed with the regular order of business, introducing Mr. Hutchison, who spoke on the following subjects:

Phonograph—Its development and final perfection. The dictating machine, for the business man.

The Telescribe, for recording telephone messages.

Motion pictures as applied to the instruction of the young.

The Edison Storage Battery.

Meeting contingencies of manufacture resulting from European War.

Reminiscences of the big fire, December 9th, 1914. Thomas A. Edison as he is today.

An Edison Diamond Disc Machine, with competent operator and selection of records was presented.

There were several models of the earlier types of phonographs for comparison. There was also an Edison Dictating Machine with transcriber, and we were specially favored by a conversation over the telephone between Mr. Hutchison and Mr. Edison, which was recorded and repeated by the telescribe, a new device recently perfected by Mr. Edison. It was said that this is the first time Mr. Edison ever talked over the telephone.

Mr. Hutchison also presented several motion picture films that were prepared to show what can be done in the way of instruction of the young in the Arts, Sciences, etc.

He also had with him samples of the Edison Storage Battery, showing interior construction, and with lantern slides showed details and uses of the battery. A sample of chemically pure carbolic acid was presented which was manufactured in the plant erected in seventeen days after an embargo was placed on the importation of carbolic acid, Mr. Edison having perfected a process and put it into execution in this remarkably short length of time.

At the conclusion, a motion film of Mr. Edison at a reception given by his employees was shown. After the meeting refreshments were served.

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HARVARD GRADUATE NOTES

A. F. Clark, '76, is with Priest Page and Co. at 145 Franklin St., Boston

H. Goldmark, '78, after eight years' service with the Panama Canal Commission as Designing Engineer, is continuing his practice as consulting engineer at 103 Park Ave., New York City.

S. J. Jennings, '85, is Vice President of the United States Smelting, Refining, and Mining Co. in charge of Exploration and Mining Investment. He would like to hear from any Harvard engineer who has a partially developed mine of gold, silver, copper, lead, zinc, or iron and who requires additional capital to bring it to a dividend paying stage. His business address is 42 Broadway, New York City.

J. E. Allison, '87, chief engineer of the St. Louis Public Service Commission recently dissolved, has donated $500 to Washington University as a fund to encourage students of the engineering department in the study of economic principles underlying the regulation of public utilities. He will deliver a course of lectures there on the organization, operation, valuation, and taxation of public utility corporations.

W. F. Atwood, '87, is a manufacturer in Whitman, Mass.

W. H. Black, '87, is secretary of the Standard Scale and Supply Co., Pittsburgh, Pa.

C. H. Arnold, '92, is an electrical engineer with the American Tel. & Tel. Co. at 15 Dey St., New York City.

H. W. Horne, '94, is Division Engineer in charge of construction of dams and pipe line for additional water supply for the city of Hartford.

H. S. Allen, '95, is an engineer with the N. C. Tel. and Tel. Co.

E. A. Reed, '96, is manager of Underwood and Underwood News and Commercial photographers. He is the author of numerous articles on visual instruction as applied to secondary education. He lectures before clubs and civic organizations on popular topics.

J. R. Healy, '97, is Inspector of Combustible, Municipal Bldg., New York City.

T. W. Clark, '98, is a civil engineer in Oldtown, Me.

E. M. Blake, '99, is Engineer in charge of the Neponset River Improvement for the State Dept. of Health.

F. W. Daggett, '99, is Superintendent of the Trenton, N. J., Filtration Plant.

R. R. Rumery, '99, has been retained by the City of Buffalo to make the appraisal of the New York Central R. R. property in that city.

J. F. Sanborn, '99, is Division Engineer in the Manhattan Division of the Catskill Aqueduct in New York City.

N. A. Thayer, '02, is an assistant engineer on the construction of the New York Subways from 42nd St., to 53d St. —Lexington Ave.

Harrison Weymouth, '02, is Assistant District Sales Manager of the Pennsylvania & Maryland Steel Co., Baltimore, Md.

H. M. Boylston, '03, is experimenting on the "Comparison of various deoxidizers used in steel manufacture" as Carnegie Scholar (1914) of the British Iron and Steel Institute. He is also Secretary of the Iron & Steel Committee, American Institute of Mining Engineers.

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F. N. Goble, '03, special student, is principal partner in the firm of Frank N. Goble engaged in Engineering and Building Construction, doing a general contracting business in the different states around New York.

S. A. Greeley, '03, is now at work on the design and construction of large intercepting sewers and sewage disposal for the Sanitary Division in Chicago.

J. H. Hall, '03, is now doing some special work for the Quigley Furnace and Foundry Co., Springfield, Mass., as consulting metallurgical engineer.

W. L. Hanavan, '03, is assistant engineer with the Public Service Commission, New York City.

Robert Livermore, '00, is manager of the Kerr Lake Mine, Cobalt, Ontario.

Charles H. Dutton, '01, is with the Rhode Island Co., Providence, R. I.

P. F. Goodwin, M. I. T., '01, is engaged in civil engineering and contracting.

K. E. Adams, '02, is Head of the Incandescent Lamp Division of the Edison Electric Illuminating Co. of Boston.

A. D. Flinn, '02, at the meeting of Municipal Engineers of New York on Nov. 25, presented a paper on "Brass in Engineering Construction," discussing failures of bolts and other articles, especially those wrought brasses, or bronzes so called.

N. G. Richie, '02, is making a specialty and study of chemistry and the efficiency of steam fuels.

J. P. H. Perry, '03, has recently been appointed Chairman of the Fire Insurance Committee of the Am. Concrete Institute. He is also a member of the Executive Committee of N. Y. Chapter National Fire Protection Association.

H. R. Ward, '03, is with the Alaska Gastineau Mining Co.

E. C. Whiting, '03, is with Olmsted Brothers, Landscape Architects, in Brookline, Mass.

W. E. Belcher, A. M., '04, has charge of the valuation of buildings for the Washington Railway & Electric Company. Considerable attention is being given at this time to the problems of valuation and appraisal, not of the transcontinental railways alone, but also of public utilities everywhere, as regulation is now the order of the day. In Washington, D. C., a special government commission is appraising the utilities of the district. The companies are also having experts making appraisal for them at the same time.

W. Low, '05, is a topographical draughtsman in the Topographical Bureau, Borough of Queens, N. Y.

T. W. Simpson, '05, is a sales engineer with the Western Electric Co., Boston.

A. H. Train, '05, is living at 257 McLean Ave., Yonkers, N. Y.

R. R. Abbott, '06, is Metallurgical Engineer with the Peerless Motor Car Co.

L. A. Andrus, '06, is a contractor in Portland, Ore.

H. E. Ditmars, '06, has been connected for the last eight years with the building business in New York City.

C. W. Kohler, '06, is a chemical engineer in Akron, Ohio.

James Otis Lyman, '06, sailed for Europe with four other Harvard men on the Chicago, January 31st, and is now in Paris working on the Ambulance Corps of the American Ambulance at Neuilly, Paris.

A. W. Shaw, '06, is employed by the Hastings Pavement Co. of New York City and has been in charge of the construction of asphalt block roads in New York and New Jersey since 1906.

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F. Towle, '06, is a civil engineer in Fort Shaw, Mont.

A. F. Clarke, '07, is works manager of the Firth-Sterling Steel Co., Pittsburgh.

A. F. Conant, '07, is at present assistant editor of the *Iron Age*.

J. V. Quinlan, '07, and W. St. George, '07, have bought controlling interest in the M. B. Foster Electric Co.

J. Weare, '07, is in the sales department, United States Steel Products Co., New York.

T. C. Desmond, '08, is now assistant engineer for the U. S. Realty and Improvement Co. on the construction of sections 4 and 5 of the new Seventh Ave. Subway in New York.

G. Mixter, '08, is in the expert department, Stone and Webster, Boston.

M. T. Rogers, '08, has been connected with the Packard Motor Car Co. since June, 1911, and is now local manager of the Buffalo Branch of that Company.

H. L. Sanborn, '08, is an electrical engineer with the Abitibi Power and Paper Co., Iroquois Falls, Ontario.

R. H. Sayre, '08, is manager of the Lake, Kansas-Burroughs, and Concrete Mines in Gilpin and Clear Creek Counties, Colo.

S. Thomas, '08, is employed as engineer in the Consulting Engineering Dept. of the General Electric Co., of Schenectady.

A. R. Clas, '09, is Secretary and Treasurer of the Falls Machine Co., Sheboygan, Wisconsin.

H. A. Allen, '10, is with the Blackstone Valley Gas and Electric Co., Woonsocket, R. I.

P. H. Chase, '10, is an assistant engineer in the Public Service Electric Co., Newark, N. J.

R. W. Coburn, '10, is resident engineer for the Mass. Highway Comm. on the relocation and construction of Humphrey street, Swampscott.

T. Maynz, '10, is an engineer with the Combustion Engineering Corporation, 11 Broadway, New York.

M. M. Warren, '10, is superintendent of the Lake Ariguanabo Co., San Antonio, Cuba.

John F. Gowan, '11, formerly with Holbrook, Cabot & Rollins Corpn. on Catskill Aqueduct, Contract No. 67, is now with Smith, Hauser & McIsaac, Inc., on Route 48, Section 2, William St. Subway.

T. R. Kendall, '12, gave a lecture on Feb. 15th before the Chemical Club of Worcester Polytechnic Institute on Sewage Treatment, Water Purification, and Refuse Disposal in Europe.

Francis W. Harvey, '13, M. C. E., '14, is with Gibbs & Hill, Consulting Engineers, New York City. His home address is New Rochelle, N. Y.

J. Morrison, '13, is with the Interstate Commerce Commission doing railroad evaluation work.

W. L. McLean, '14, is a student in the Boston Normal School observing the work of the Boston public schools.

E. L. Robinson, M. C. E., '14, is with the Terry and Tench Co., of New York in connection with the Manhattan Elevated Improvements. His address is Milliken Bros. Inc., Milliken, Staten Island, N. Y.

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What do you know about a Harem?

A Tech Student from Turkey tells all about it in the May issue.

I—I sent two tomato cans to the Ford factory last week.

Kie—Uh huh?

I—And today I got a telegram saying, "What shall we do with other can?"—Purple Cow.

AN OLD ONE

"What little boy in the class can mention a memorable date in Roman history?" asked the teacher.

"Antony's with Cleopatra!" ventured one of the boys.—Froth.

"Last night Jack tried to put his arm around me three times."

"Some arm."—Yale Record.

IT HAD TO BE DID

Minister—Brother, it pained me greatly to see you come out of a saloon the other night.

'15—Me too, but it was closing time.—Gargoyle.

Physics Instructor—"Name the unit of power, Mr. Jones."

Jones (waking up)—"The what?"

Instructor—"Correct. Any questions? All right. We have a few minutes before the end of the hour in which we will do this problem: A man on a bicycle approaches a 4 per cent grade; how far has he come and will he have to get off and walk?"

—Cornell Widow.

HE THOUGHT HE HAD

"How about your Pol. Econ!"

"I dread it."

"Then you had read it."

"I dread it."—Widow.

She—"Isn't it strange that the length of a man's arm is equal to the circumference of a girl's waist?"

He—"Let's get a string and see."

—Jester.

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Local Color

We publish two kinds of jokes: good jokes and Professors' jokes.

WISDOM IN APPLIED

Professor Johnston—We see that in this case the difference between X and Y is zero. What does this mean?

Knowland—Nothing, sir.

DEEP THOUGHTS IN THEORET

Professor Sherrill—I don't want you to memorize these facts; just—just—well, remember them.

THIS FROM FRESHMAN ENGLISH

Mr. Goodwin—I had a girl once—I mean I had a girl in class once,—

Student—That's worse.

491 Boylston St., Boston, Mass.
Mar. 19, 1915.

To Boston Elevated Ry. Co.,
Boston.

Dear Sirs:

Please accept my application for a position as street car conductor on your lines. I have had no previous training in this capacity except in collecting subscriptions to a monthly magazine, but I feel fully competent to hold down the job, and I may also state that I shall not have to be supplied with a uniform, as I have a very fine one, only four years old, in which I used to drill before I left the Institute of Technology. I am 18 years old, and am tall enough to reach the bellrope.

Hoping you are the same, I remain,
Yours as usual,
James F. Douley, S. B.

P. S. I am a poor boy.

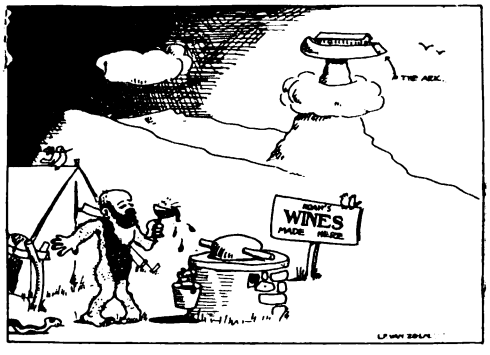
A farmer to the Chem. lab. strayed,
And (oh, 'tis sad to tell),
Mixed glycerine with NO 2,
And it blew the J 2 L!

—Siren.

PUZZLE

An organic chemistry textbook has 600 pages and over 100 cuts. It is printed in England and sells in America for $1.50.

What would be its price if it were published by an American Professor?



—NOAH MAKES PORT AFTER THE FLOOD—

Prof. Smith in Applied (pointing to the diagram on the board)—What point shall we take next, Mr. Hawes?

Hawes—Let me see, I guess you had better go to H next.

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GETTING A RISE OUT OF HER

The shaded lamps placed 'round the walls threw a dim, soft glow over the drawing-room of the sorority house. From another room the sweet, gentle strains of a Hungarian rhapsody floated through the open portals. Ruth and Harold were alone in the large, beautifully decorated drawing-room.

"Ruth," he said, very softly, "I'm engaged—"

"Oh, Harold," she quickly broke in, "why, why have you done this? Didn't you know that it would hurt, that—"

"But Ruth, I'm—"

"Yes, yes, I know! You needn't explain! It's over now!"

"Wait, hear me!" he said quickly, "I tell you I'm en-—"

"Say no more! I've noticed for a long time that you weren't the same."

"But listen, Ruth! Give me a word! I'm en—"

"No, no, never mind! I've known it for a long time and it's worried me; it isn't any surprise, but—"

"Ruth, you must listen to me! I'm en—"

"Go no further, Harold! Do you think I'm blind! I could see all the time what it was. The change in you told—"

"I'm engaged," he said suddenly, "to sell magazines next summer!"

"Er—r—r— why—er—r— yes, of course! Naturally, the change in you told me that you were worried by business troubles," she said, making a quick recovery.—Gargoyle.

HOW SOME GREAT PEOPLE STARTED THEIR QUARRELS WHEN THEY WERE KIDS

Christopher Columbus—"I'll land on you."

George Washington—"Tell that to somebody else."

Michael Angelo—"I'll jump on your frame."

Galileo—You'll get something you're not looking for."

Dr. Wiley—"Do you want to get cleaned up?"

R. G. Dun—"Who are you, anyway?"

Eve—"G'wan start something."

—Gargoyle.

One—Jones borrowed an old piece of roofing,
Two—And sent it to the Ford people
Three—Without any explanation.
Four—Yesterday he got a letter from them.
Ohow—They said—,
Iwish—"It must have been a terrible accident.
Therwer—We are sending you a new car
More—By the next mail."

—Purple Cow.

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THE CALENDAR

APRIL

1. *FOOL'S DAY.* Adam desires removal of more ribs, B. C. 2,731,-007.
2. Accession of Fu-hi, reputed inventor of writing, B. C. 3322. *
3. First Olympic Games (World's Series) begin in Elis, B. C. 776. Coroebus wins the foot race.
4. Games continue, B. C. 776. World renowned miler, Bacchaechus, disqualified for jumping the gun.
5. After 400 years of struggle, the North Pole still remains unfound, 1909.
6. Peary discovers the North Pole, 1909. The Earth continues to revolve, 1909.
7. "The White City by the Charles" declared to be almost completed, 1925.
8. Vesuvius erupts, after refusing to adopt Safety First precautions, 1906.
9. Information bureau, Rogers Building, gives out information. (?) **
10. Count de la Rochejaquelein in favor of simplified spelling, 1792.
11. Visitor in Boston mistakes Walker Building for Brunswick Hotel Garage, 1915.
12. Julius Caesar, named after a Shakespearian play, bites the dust, 44 B. C.
13. Thomas Jefferson born, 1743. Niemand Zu Hause still fresh in Tech men's memory.
14. *Technique*, second greatest publication at M. I. T., may be, 1915.
15. President Lincoln calls for 75,000 volunteers, 1861.
16. President Lincoln wishes M. I. T. were in existence, 1861.
17. Fair maidens smile upon Tech men and ask, "Don't you work awfully hard?"
18. (Sunday) Tech men take their sisters (et aliae) around Back Bay promenades, where they have not promenaded for a year, 1915.
19. Junior Prom begins, 1915.
20. (x A. M.) Junior Prom ends, 1915. *Au revoir*, happy days.
21. Persia declares "endless peace" with Eastern Empire. A. D. 533.
22. Persia renews war with the Empire, 540.
23. Definite peace between Persia and the Empire, 563.
24. Boston "News Letter," the first regularly published journal in the United States, and after which Boston newspapers are still modeled, established, 1704.
25. War renewed by the Empire, 571. Persia protests against alleged barbarian warfare of the empire.
26. Students discovered hard at work in Cambridge, 1915. (Rumor)
27. Andrew Carnegie gives $10,000,-000 pension fund for college professors, 1905. The Faculty at M. I. T. threaten to retire, 1905.
28. James Monroe born, 1758.
29. James Monroe thinks South America unfit for colonization by Europeans, 1758.
30. French government replies, "Oui, oui, mein Herrn," when offered $14,999,998 by U. S. for Louisiana Territory.
31. (Deleted by censor).

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*Curses on thine invention.—Editor.

**Interrogation mark unnecessary; this is the TRUTH.—Editor.

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Lady Customer—I would like a pound of sulphur, please. How much is it?

Druggist—Fifteen cents a pound, madam.

Lady—I can get it for ten cents across the street.

Druggist—I know it, madam, and there is one place where you can get it for nothing.—Jester.

GO TO THE HEAD OF THE CLASS

Prof.—"Can you name a liquid which won't freeze?"

Stewed—"Hot water, sir."—

—Cornell Widow

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Husband—But I was *fired* with love,

The She—And it was a good *match*—

Husband—And I was an old *flame*—

The She—But he *scratched* and *struck*,

Husband—And she *flared* up—

The She—Then he *went out*—

The Judge—No, you cannot make *light* of this *match*.

So they put their *heads* together.

—Gargoyle.

Suffrage Speaker—Have I made myself plain.

Voice in Rear—No—Nature.

—Gargoyle.

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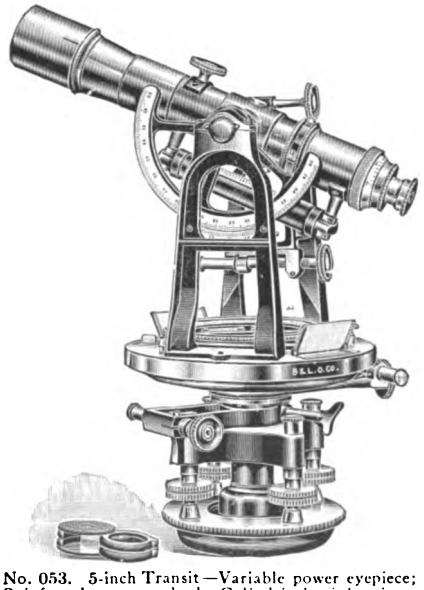

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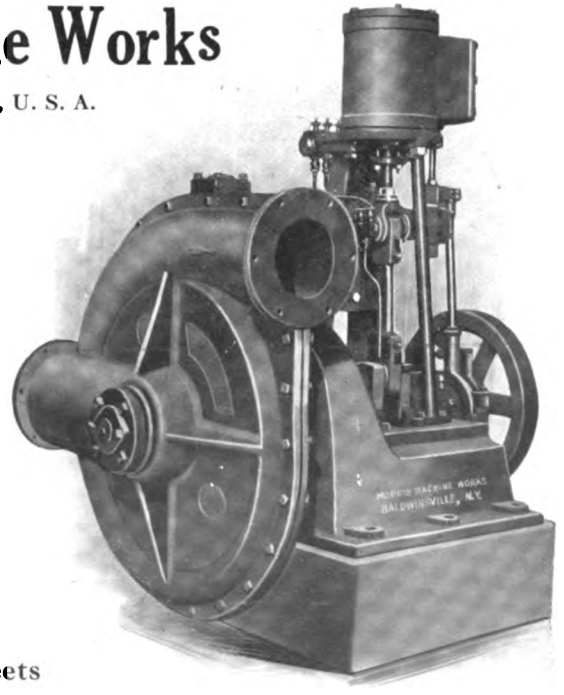

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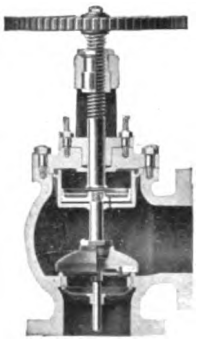

Fig. 293
Sectional View of Automatic Stop and Check Valve, Angle Pattern

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Entered as second-class matter at the post office, at Boston, Mass. Published monthly during the college year by the students of the Massachusetts Institute of Technology. Publication office, Technology Union Building, 42 Trinity Place, Boston. Harvard Editorial Office, 218 Pierce Building, Cambridge, Mass.
Mail Address: Technology Monthly, M. I. T., Boston, Mass.
Phone Back Bay 2180, Private Exchange

Subscription rate, $1.50 per year; 25c. per copy. Advertising rates upon application.

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THE TECHNOLOGY MONTHLY
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VOL. II BOSTON, MASS., MAY, 1915 NO. 2

MOTOR TRUCK EFFICIENCY

By M. T. ROGERS
of The Packard Motor Car Co. of New York

EVERY business man is willing to admit that the Motor Truck is here to stay—some have already accepted it as part of their equipment—others are loath to make the change from the old reliable horse-drawn vehicle. Probably only a small percentage of owners have made careful and complete studies of the problems surrounding the use of a truck; the larger percentage at present is using motor vehicles more as a matter of service than as a matter of efficiency. Inefficiency is the greatest crime to which we as a country must answer. The purpose of this article is to call attention briefly to some of the more important general points to be considered in the operation of a truck and to cover in greater detail certain conditions with which operators have to contend. These conditions vary considerably, for the reason that the truck, if it is really to become a useful tool of business, *must* be made to perform, not only because of the service it is capable of rendering, but because its cost of operation is within the limits prescribed by a successful business.

The efficiency of a motor truck depends on three general factors: the truck's ability, working conditions, and the administration governing its operation. Definite rules may be laid out for the first and last, but the second demands careful individual study on the part of the owners.

Briefly, under the first heading, the prospective purchaser should consider first and foremost the manufacturer behind the truck—whether his article has been produced as the result of long experience, careful engineering design and study of the general trend of the business, and whether his organization has been built up with quality as the standard, integrity as the watchword, and based on a sound business policy which fully appreciates the need of efficient and widespread service to the customer.

Taking up the third point next: the administration governing the operation would naturally include the management, both in the office and outside, and the general method of accounting. The latter is very important, as by it the owner can have an accurate record of the complete operation—it should include full figures on the truck in service, out of service, running loaded, light, time of loading and unloading,

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together with distances covered under the same conditions and complete operating costs in addition to fixed charges, based on first cost, amortization, interest, insurance, and overhead. From these records can be obtained the actual cost of performance, preferably figured in terms of weight or capacity-mile (such as ton-mile; cubic-yard-mile, etc.). While the importance of such information cannot be over-estimated, as from it the owner knows immediately whether or not his truck operates less expensively than would other means of transportation, this is a complete subject in itself and the writer would only suggest the advisability of using suitable forms for the keeping of such records.

The first element governing the successful operation of a truck is the human element—the driver. While the writer would not presume to advise employers in their choice of employees, experience has shown that the average truck owner does not give this point sufficient attention. A motor truck is an expensive article—it represents a large investment—it works under conditions much more severe, is subjected to varying loads and rapid changes of speed and if not properly handled and cared for is a menace to public welfare; it is entitled to proportionally as much care and attention as a locomotive; consequently, a motor truck can be ruined in a day, or with careful handling can be made to last for years. A good truck does not require an expert mechanic, but any piece of machinery needs the attention that can be given by any thoughtful person,—plenty of lubrication, sufficient water for cooling, and care in the taking up of wear on various parts. The driver's intelligence, energy, and skill, therefore, are very important items to consider.

The purchaser should consult the agent who sold the truck (most agents have lists of available drivers) and insist that he give the driver full instructions relative to its operation, and see that these instructions are obeyed; the employer then allows the driver time to give his truck the attention which the engineer gives his engine—which the lover of horses gives to his valuable stock.

The other element under the control of the truck owner is the shipping department. Here is a point which cannot be too carefully considered. A truck, to be efficient, must be kept running—working to capacity. Its ability to perform work is tremendous; a two-ton truck, for instance, loaded, and operated at a speed of fourteen miles per hour, can do 280 ton-miles of work in a ten-hour day, as compared with the average ability of a two-ton team to do 80 ton-miles.

Although the cost *per mile* of the truck is greater, under conditions where it can be kept running, the cost per *ton*-mile of the truck is less. One will appreciate, therefore, why careful attention should be given to the one thing that can be closely controlled, the shipping facilities.

Accessibility also is of prime importance and while many conditions will affect it—buildings already in position, restriction of room, city regulations as to time sidewalks may be blocked, etc., they should receive careful study; a manufacturer will conduct time studies on his workmen—why is it not just as important to study ways and means for speeding up the loading of his truck? In the line of equipment various types have been used: John Wanamaker uses "nest bodies," loading up crates on the shipping platform and transferring the entire crate to the truck. This permits a minimum time for standing. Lumber dealers use slings and horse "loading

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trucks" which gather the load in the yard and transfer it to the truck by means of the sling; others have overhead cranes. A brewery has a specially adapted conveyor, taking out kegs and depositing them in the truck body. Special devices may be designed for particular duties—the point which it is desired to emphasize is the absolute necessity of a complete study of the loading problems, so that every controllable feature in the truck's operation may have attention.

The wide awake truck operator of today is appreciating more and more the importance of these things, with the result that there are several standard loading devices on the market, which do away, to a certain extent, with special designs.

We come now to what may be termed uncontrollable working conditions—conditions which every truck operator must face and investigate for himself; and which, if not given proper attention, are apt to make just the difference between efficient and inefficient operation.

The hauling distance is the first point —the longer the haul for the truck in any business, the cheaper the relative cost of transportation. Careful operators know that within a radius of five miles a team of horses would deliver ten tons of material in a day, with average loading facilities, taking one load in the morning and one in the afternoon, perhaps, for $5.00 or thereabouts. A five-ton truck would do the work in half the time or less, but might be useless for the remainder of the day, because after doing this particular piece of work it would have no time for a long trip and would be held up till the next morning. Such a condition would more than double the cost of delivery. In the cost performance curves of wagons and of trucks is a certain point where the two intersect; beyond that point horses are less efficient than trucks, other things being equal. Therefore, while there are exceptions to the rule, keep the heavy trucks hauling long distances; let fleets of light vehicles or horses handle the business closer at hand.

Few operators give a second's thought to the routing of their trucks—a driver is instructed to go to a certain point, but he is not told *how* to get there. Bad pavement, traffic congestion, short corners, necessity for backing, and grades—all things which tend to delay a truck—cannot be controlled. They can, however, be avoided. The writer is aware of instances where the transportation manager has a city map before him at all times; he spends certain hours during the week investigating street conditions; from his study of the road he can direct his drivers as to which streets to avoid and which to use, knowing as he does that poor pavements most certainly shorten the life of a truck. The writer also knows of one large storage and moving company in Philadelphia which absolutely refuses city work for its large trucking units, because of length of haul, and jobs which call for country travel, because of its leading the trucks away from improved highways. The firm estimates that standard prices charged by truckers are not sufficient under conditions cited, to cover increased cost, due to short hauls or more repairs, on account of bad pavement, and prefers to lose the business, rather than operate at a loss. The result is that these trucks are in good condition and they are doing a good business with a reasonable return on their investment,—though confining their efforts to the limits mentioned.

Traffic congestion is an important element. Fire departments have long met these obstacles by means of electric

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systems, which show on maps certain routes to follow to every box. These routes are chosen (1) because they are shortest and (2) they keep the apparatus away from the main streets of the city. Why not have similar arrangements for trucks? "Time is money" for the commercial vehicle as well as the fire truck, and the operator who is obliged to suffer least in loss of time, through his truck's being held up by congested traffic, is sure to get the better of his competitors.

A case came to the writer's attention a short time ago, where a company paid an efficiency engineer to have its business studied and systematized; the truck, a two-ton, large body vehicle (since the company's product was light) came in for its share of investigation. Tommy, the driver, came to us for advice, saying that the efficiency fellow was "giving him too much." He was allowed so many stops per day, each one of so many minutes, etc., having an average figure set, above which he received a bonus, and below which he was penalized. The efficiency expert overlooked the traffic proposition, but the writer went into it with Tommy and in the first week he earned $1.90 more than his salary. They raised his "average mark," but even now the driver seldom falls below and usually gets his bonus. He keeps away from Main Street, knows the best paved streets, chooses the cobbled, hilly streets and not the smooth-paved and because he is an exceptionally good driver and appreciates these things, is making money for his company and himself. Truly, one cannot control congested traffic; but ordinarily, one can avoid it.

Backing is just one of the points which the average operator overlooks, but it surely is worth studying. Backing takes time and is often hard on a truck. The driver, with a large body on his chassis, cannot readily gauge the position of a curb and is apt to hit it hard with the wheels, the resulting shock of which is bad for tires, wheels, and frame. Bodies opening from the side will help as will thoughtfulness on the part of the driver, who should be taught that while it might be harder for him, he could carry some article he was unloading a few steps farther, perhaps, and thus save time and wear on the truck.

Grades should be avoided where possible; where impossible, choose a cobbled street for the ascent and a smooth paved street for the descent. Although it may be considered that these are ideals only, toward which one should strive, yet a person would be surprised to discover how they could be worked out. Buffalo, for instance, is very flat; at one point, however, there is a slight rise, with two parallel streets leading to the top. One is paved with stone for about a hundred yards below the foot, while the pavement of the other runs only to the beginning of the little hill. Our truck drivers are instructed to use the shorter pavement for all occasions and we generally use it for the touring cars as well. This phase of the grade question is not highly important, yet it counts in the long run. Another point in connection with grades, aside from escaping them where possible, is the tendency of the average driver to force his truck to take them on high gear. The tendency is natural, the result of custom in the operation of pleasure cars, for in the latter class people have for some time measured a car's ability by what it can do on a hill in high gear. Fortunately for motor car manufacturers, this idea is gradually being corrected. People are beginning to appreciate that a gearing which

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reduces the speed of motor for average driving speed is preferable and that it is much better to drop back to a lower gear on the hills, being easier on motor, tires, and entire car. The same condition should prevail on the truck and drivers should be cautioned against abuse of this nature on gears.

Much as one dislikes to admit it, we shall have to concede that, to date, snow and mud present conditions oftentimes fatal to truck operations. It is purely a case of getting sufficient traction—the *power* to pull is generally present, which is not always the case when horses are being used. Keeping a truck heavily loaded will overcome the snow problem, but for bad mud holes no remedy has yet been discovered. It is encouraging to know, however, that better roads are being built everywhere, and as road conditions improve the use of trucks will steadily increase.

Steadiness of tonnage is greatly to be desired, of course, but is not always attainable—generally speaking a truck costs as much to run empty as loaded; therefore, keep it loaded to capacity as long as possible—in other words, diminishing load conditions are not generally successful for truck operation.

The operating schedule and the steadiness of the load are two uncontrollable features which need attention. It makes for efficiency, of course, to keep a truck on schedule time, but practically all of the elements previously mentioned likewise affect that point, so little more can be said. By all means however, a fair schedule should be fixed and a driver kept to that: the case of the driver previously cited shows what can be done, and how it will redound to the advantage of the owner.

The last feature is a large one—receiver's co-operation. We can best cover that point by suggesting that the receiver as well as the shipper study trucking conditions with an eye to efficiency; each will then appreciate the things with which the truck has to contend, will realize that truck operators are working to serve him, and that by measuring their ability to accomplish work, he is improving his own opportunities. About the same conditions control the receiving as the shipping, and careful study and application of efficiency principles will do much to improve results in general.

We are all working with improvement in mind, of course, but in the hurry and scramble of present-day business life, one finds little opportunity to sit down and really solve a problem as he used to do in his algebra class of high school days. Such detail work is left for specialists—and specialists are sometimes expensive. The trucking problem is not an intricate one—it merely requires good common sense; but it is becoming more and more important. Why not pause for a moment, consider some of the points brought out herein, and ask yourself, if you are a truck operator, "Am I doing things efficiently"? or if an owner, "Will a truck, handled in this way, reduce my transportation expense and give the service that will help build up my business?"

The business structure is founded on these two elements—service and efficiency. As they are improved and increased, business conditions the world over will be better.

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OUR FRIEND, THE TEXTBOOK

By CHARLES STILLMAN MORGAN, A. B.

Editorial Note: Mr. Morgan's name is not a new one to the readers of the Technology Monthly and Harvard Engineering Journal. His article on The College Professor's Technique, which was published in the November issue, presented some original ideas concerning the requisites for members of the engineering school instructing staff. In his second article Mr. Morgan deals with the subject of textbook abuses.

NUMEROUS difficulties beset the student of today, despite the tremendous efforts of those behind college desks to give the student a start in life which at least approximates that individual's capacity for being started. In an earlier article certain suggestions were offered which were thought to be corrective of faulty teaching; in this second article let us give similar attention to the textbook.

To obtain a proper perspective from which to view our problem let us take a glimpse at the history of textbooks. We may say that textbooks are of comparatively modern origin. Teachers of former days gave their instruction verbally without the use of the written or printed page. But with the rise of educational institutions on a vast scale it was seen that men of lesser caliber must be pressed into service if all who sought instruction were to be supplied therewith. For these lesser men there had to be devised tools by the use of which the thoughts of master minds could be made available to that great horde of students which modern times have produced. These tools we call textbooks.

This exceedingly brief historical sketch should have given us our cue as to the nature of the textbook. Theoretically and historically we can say that the textbook should be the product of only the greater minds, embodying new thought never before known to mankind. Since such books are always few in number and since their originality puts them beyond our petty criticism, we shall devote our entire attention to a second and more common type of textbook: viz., that which merely works over, recasts the thoughts already available of the great thinkers in the various sciences. Such books must submit themselves to two searching tests: first, do they make use of the tried and true methods of pedagogy; second, do they improve thereon? That a book must meet our first requirement is obvious; that it must also meet the second requirement is reasonable in view of the fact that the author calls the book into existence in order to work over material already available in a somewhat presentable form.

Our contention is that about one book in three can meet *both* of these requirements. The vast majority of books do not in any important way improve on their predecessors, while those that do in some few respects, are apt to fail elsewhere.

To make our criticism of textbooks more clearly logical we shall group it under three heads: (1) A criticism of style; (2) a criticism of matter; (3) a criticism of the attitude of the writer toward the pupil and toward the teacher.

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How easily stated but with what difficulty realized is the standard of style which we shall set up. It would seem that in writing textbooks, at least, Spencer's rules for the economy of the reader's time would be standard enough. Surely there is no place in a textbook for an especially virtuous style but still it is equally true that textbook style need not be sketchy or crude or hackneyed. Between these two extremes, embellishment on the one hand and bleakness on the other, the particular needs of the subject should determine a particular textbook's style. That a book on rhetoric should tend one way and a book on boilers in the other is obvious; but that the writer of the second need mind only his steam tables, charts, and diagrams, unmindful of the nerves of his readers, is not so obvious.

There come to mind two excellent illustrations of what textbooks should not be. Both treat of the same subject, which, by the way, is fairly exact in nature. One reminds the reader of the commencement orations of June graduates, so everlastingly is it given to roundabout ways of saying the obvious. The following is typical of the book: "The reader will please note that nothing definite is yet known on this subject. What we do know is mostly conjecture. (Three to five page gone). Therefore let us see both sides of this question. (Then follows ten more pages attempting to help us to do this). Now, having weighed carefully, considerably, and candidly the two sides of this momentous question let us draw our conclusions. Our conclusions are that there is no conclusion. Perhaps some day there will be, but at present he would indeed be rash and unphilosophical who would venture to go farther than we have gone." Whereas twenty-five pages were used for all this "much ado about nothing" another writer could have put it all in five and, what is more, given the reader something definite to carry away.

The other book referred to fails for exactly the opposite reasons. It is not only wordy and hesitating; it is brief and dogmatic. One could easily mistake it for a laboratory manual in, let us say, qualitative analysis.

Moreover, a great many books otherwise satisfactory in style fail in smaller matters. Thus many books disgust the student with the ever-appearing statement that such and such a point is "obvious" or "evident" when such may be far from the case. Like the item "miscellaneous" in the budget rendered by the student to too cautious parents these words cover a multitude of sins. Both include a great many things "too numerous to mention," "not worth mentioning," or "impossible to mention." This is the attitude of the writer who lapses into the habitual use of these terms; he is trying to get some place and does not care how he gets there.

Under our second score of criticism we shall lay down and illustrate one dogmatic rule. The question up for consideration here is in regard to what matter shall be included in the textbook. Of the need of including that great body of accepted facts there can be no question; the trouble arises when there is included in the book material of doubtful validity. It would seem that the only safe thing to do would be to exclude all but the most widely accepted facts included in the field of any particular science. This, then, constitutes our ruling on this point. For illustration we can cite an extensively used textbook in one of the exact sciences which has caused untold an-

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guish to a vast number of students who learned too late that the book was built on a faulty hypothesis. Instance of this kind are far from being rare.

Our third and last score of criticism was in regard to the relation of the textbook to the student and to the teacher. First, what should be its relation to the student? It should be a guide, enabling the student to connect each day's work with the common purpose underlying all his work. It should be a container of a great body of undisputed facts to which the student can fasten himself. But in addition it should aim to stir up an interest in the student that will not be satisfied when the particular course is finished, but which will be lasting throughout life. President Emeritus Eliot's idea that education is a process which should cover the individual's whole life and not merely the first third thereof is suggestive in this connection. The student's interest should be so aroused that he will be eager to "contribute" something to the science. He then throws off the attributes of the student and becomes the scholar. Too many books cause the student to believe that his "contributions" are not wanted and might therefore better be left unattempted. In other words, some books suppress all the individuality which the novice may normally be expected to have.

This last point ushers in a consideration of the teacher. We shall assume that the teacher is not the writer of the books which he uses, however rash this assumption may be in the view of the all too common practice of college professors to write books for their own classes with no "provocation" whatever. We have in mind some books whose only possible excuse for existence is found in some minor variations on other books, as, for instance, in nomenclature.

Our general rule here is that great personalities know no textbooks. A mediocre teacher will attach himself slavishly to a textbook; the great teacher will want to do things in his own way. Herein we have the explanation of the rise of the lecture system. The danger with it is that it may be made use of by men who can not make up in suggestiveness for what the system can rarely attain; viz., as exact and careful a presentation of the material as can be obtained from the use of the textbook method. It is true, however, that even the great teacher will like to have a textbook used by his student, provided it is always kept in the background. It must support but not outshine his own personal teachings.

From this discussion we can draw the conclusion that the needs of the student and those of the teacher are much the same. Both want the textbook which they use to be handy but not obtrusive guide, a source book of available and undisputed facts, and a source of suggestions that may lead the user into new fields of thought. We can see that the textbook is a tool, a companion, but not a master; that it should open the eyes of the student as a stimulant and not close them as a soporific; that it should give the teacher something definite to which to refer his classes, but not something so definite as to make the teacher merely a retailer of the ideas of others and the student a superstitious believer in the absolute validity of all that the book recites.

If textbook writers were to keep these requirements in mind how many fewer would be they early crop of texts, but how much better might be those fewer books which survived, since they could be assured a much more extended use.

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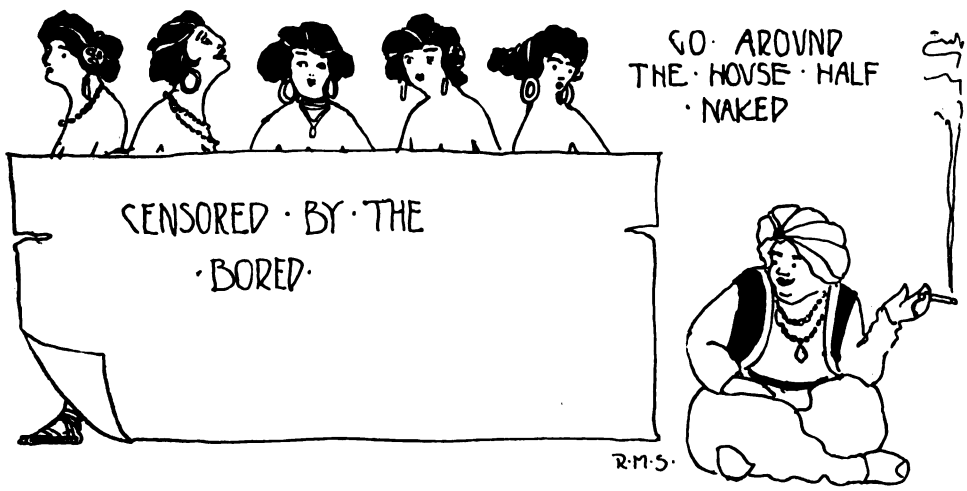
THE HAREM*

By JOSEPH FARHI, M. I. T., '16

THE very first day I landed in the New World an American young man whom I met in a hotel in New York asked me this apparently simple and honest question: "How many wome can one marry in Turkey?" Since then a number of business men also asked me the same question over and over again, but I must confess that I never expected to find also so many serious and well educated Tech students eager to know "a lot" about the harems in Turkey.

In the old times the fair sex of Arabia was treated unfairly and had mighty few rights, if any at all. Mohammed, the great Arabian Legislator, noticed the miserable condition of the women of Arabia and therefore decided to protect them and in his famous "Horan" assigned some right to the women. For instance, he limited the number of women one could marry but found it unadvisable for his times, at least, to establish monogamy, although he himself had only one wife, Kadija. He also thought it best to forbid women to show their faces and hair to any man unless he is a keen relative of hers. That is the origin of the "sharshaf" and the "harem."

The "sharshaf" is a kind of thin dress, now quite often transparent, which the Mohammedan women wear over the ordinary European dresses. The upper part of the sharshaf is in the form of a pelerine which covers also their hair. A very thin transparent piece of cloth covers the face; it is usually black or white silk; this piece of cloth can be raised at will. At present



a great many Turkish women are going without the veils on their faces.

The place where the women gather, their private rooms, is called the "haremlik" and is also called the "ha-

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rem," although this name is also given to the women in a family.

We see, therefore, that polygamy is not forbidden in the Turkish religion nor in the Turkish law; hence some of the excesses which you have heard about in an exaggerated form.

Owing to modern civilization and, I might also say, owing to high cost of living, a modern Turk does not marry more than one wife. In fact in the big cities polygamy is so uncommon at present that I do not believe that those who marry more than one wife number more than one or two one-hundredths of one per cent in each big city. The princes usually have a harem, but even that is being dropped little by little. The second heir apparent to the throne of Turkey has only one wife. Not many decades ago many of the high dignitaries of the Empire of Turkey had more that one wife, but a radical change has been going on during the last twenty or thirty years. The present Sultan has only four wives and only one of them is his real wife, the others being the second, the third, and the fourth Lady of the Sultan. In the interior of Turkey the conditions are a little different but by no means as bad as many imagine it is, and I feel right in saying that within very few years the interior will be as advanced as the big cities of the Empire.

But every Mohammedan has a so-called harem. Now suppose for a moment that you are a Mohammedan and have a wife and two daughters, and suppose that a college friend of yours comes to visit you, or anybody else, and suppose you want to have dinner with him in your home. Religion forbids your wife and daughters (if they are over fourteen) to be in the company of strangers (men) with uncovered faces; therefore they must have a place of their own where they can have their dinner and where, as is almost always

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the case, they can stay until the visitor leaves. That place is the haremlik and your wife and two daughters form your harem. Does that mean that your two daughters are your wives; does that mean that you have three wives?

Young men all over the world think that in a "harem" a number of women, who care about nothing but their physical beauty, go around the house half naked, taking baths of perfume every now and then, then lying nonchalantly on couches in the middle of large rooms whose air is always saturated with some enchanting incense. They go still further, as if that was not enough to make them realize how foolish their imagination is; they think the women in the "harem" are constantly attended by a number of other pretty slaves forming a second "harem" in the same house. Of course these dreamers picture all these women Waiting Anxiously for the arrival of the "master" of the house!

The fair sex, in all countries, particularly those in the U. S. A. have, it looks so to me, a greater power of imagination and in consequence whenever they think of Turkish women they think of a line of young girls tied one to another by a chain and carried thru the streets by their "owner" and liable to be sold in the markets as cattle are sold; or they think of them as kept always in a dungeon and being beaten whenever the "master" feels like beating them.

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I may have cited extreme cases but this kind of imagination is not uncommon in Boston.

I understand that in the centuries gone by there used to exist conditions similar to those mentioned but those times are those with which modern history has nothing to do.

The condition of the women in Turkey is not as bad as you think it is; not even one-tenth as bad as you imagine it, for we love our wives as dearly as any true lover loves his sweetheart, and family life is as dear to us Turks as it is to any true American husband and father. To show you that even in Turkey the man is not always the master of the home, I will quote an old Turkish saying: Women can make heaven or hell for a man in his home.

Education is provided for the Turkish girls; they have their own public and private schools, (elementary, grammar, and high). Unfortunately education is not obligatory in Turkey; however a great number of the Turkish girls are eager to go to school and obtain a good learning. Since 1908 there is going on in Turkey a great progress in the spreading of education among the girls and women as well as among the men, although the Christian nations of Europe have been raising many obstacles in the form of wars, to keep us, the Turks, away from progress so that they might have us always under their mercy. Some Turkish girls also attend foreign colleges; as an example I will mention the "American College for Girls" of Constantinople where there are quite a number of Turkish girls studying the English literature, etc. under Dr. Patric, a famous Bostonian lady.

As the majority of the men in the big cities of the Ottoman Empire, many of the Turkish women can speak and write fluently one foreign language and sometimes more. Many women can play a musical instrument, and many cultivate their voices.

A Turkish woman can go out and does go out, and nobody will object to it as long as she wears the "sharshaf" of which she herself is so proud, by the way. She goes often to visit her lady friends and often too she entertains them in her home.

The women in Turkey are also beginning to express their wishes of having "equal rights" and they are doing their best to show us, the male population of the Ottoman Empire, that they deserve it or will deserve it ere long. They have answered in a wonderful way to the call for donations for the building of new battleships; a great number of them turned over to the government their most precious jewels and their

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earnings without the slightest regret. They are publishing a paper edited entirely by women and of course defending and advocating their "cause."

In the farms of Turkey it is not at all uncommon to see the women working in the fields.

Perhaps you would like to know how they get married in Turkey. Well, it is most like anywhere else in the Near and Far East, that is to say "his" parents ask "her" parents for the hand of their daughter in behalf of the bridegroom to be. If the parents of the girl agree, the young folks decide whether or not they care to marry the other party; if they do care for each other the first ceremonies take place immediately. From there on there are a lot of visits paid on both sides, meanwhile the young couple can study each other's character and after an indefinite period if they still care for each other the marriage ceremonies are held. Generally, however, the young man and the young lady have had occasions to meet before their parents intervene, and I think this last fact will put at ease the mind of some of the readers of this little essai.

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COLLOIDS IN THEIR RELATION TO BITUMINOUS ROAD CONSTRUCTION, THE ASPHALT PAVING AND OTHER INDUSTRIES

By CLIFFORD RICHARDSON, H. U., '77

A CERTAIN state of matter is known as colloidal. This is not limited to a particular class of matter since, according to recent conceptions of the subject, all substances can be brought into this state by appropriate means. Matter in a colloid state is characterized for the purposes of this paper by the very high degree of dispersion in which it exists. For this reason, the chemistry of the subject has been called Dispersoid Chemistry. It is distinguished from the colloid chemistry of previous decades, according to which a colloid was necessarily a non-crystalline substance, by the fact that it is now known that crystalline substances also can be obtained in colloid condition by suitable manipulation, using a medium or phase which does not form a molecular solution with the substance or crystals which are to be subdivided or dispersed. A disperse colloid must exist in a system of at least two phases, an internal or disperse one which may be solid or liquid, and an exterior or a continuous phase in which it is dispersed. The main characteristic of the disperse phase, if a solid, is its state of subdivision or degree of dispersion which, in order to constitute it a colloid, is ordinarily carried to such an extent that the particles are as small or smaller than .0001 mm. in diameter, and in the case of some solids no larger than .000,006 mm. The peculiar characteristics of disperse colloids lies in the enormous surface area which they present in comparison with the amount of solid material which they represent, the great surface energy developed thereby, and their capacity for selective adsorption. A realization of this may be arrived at from the fact that if the amount of material represented by a cube, one side of which has a dimension of one cm. is reduced by decimal subdivision only to the coarsest colloidal size, a ten-thousandth of a millimeter in diameter, the number of cubes produced would be 10 to the 15th power, while the surface would be increased to 60 square meters or 100,000 times more than that of the original cube. The enormous surface area displayed by colloidal material is, in this way, made evident. The chemistry of colloids is, therefore, one of surface, of films and has a large bearing on bituminous highway construction.

A substance existing in a colloid state or solution differs from an ordinary solution in that, although highly dispersed, it is not in a state of molecular diffusion. For this reason colloidal solutions do not readily diffuse through semipermeable membranes in the manner observed with molecular solutions. This can be illustrated by the formation of colloidal silica by adding an acid to a solution of silicate of soda. A jelly-like mass of colloidal silica and common salt are formed with water. The salt can be removed from the jelly by diffusion through a semipermeable membrane, into water, owing to the fact that it is in molecular solution. The

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colloidal silica remains within the membrane containing it. By appropriate means, a different medium, in which the salt does not form a molecular solution salt can be obtained in a colloid condition. This reveals the fact that the colloidal state is one which applies to all matter, crystalline or not, and is not applicable to a particular class only. A study of colloids, therefore, involves a study of a particular state in which matter exists, and involves properties conferred upon it by its high state of dispersion, such as the power of selective adsorption, without being in molecular solution. It is a condition characterized by an enormously extended surface area for a definite amount of material so existent.

Another example of the colloid state is displayed by the metals in a high state of dispersion. Gold, for instance, can be obtained in such a condition by the reduction of a very dilute solution of its salts with appropriate reagents, in the form of a ruby red liquid in which the gold particles remain suspended indefinitely, and from which they cannot be separated by subsidation, filtration, or any ordinary physical means. This is known as a colloid solution or simply "Sol." In this case water is the phase in which the gold is dispersed, but other liquids may serve for the purpose. In the bituminous paving industry sols are found in which the disperse phase is clay and the continuous or external phase is bitumen. A sol of this description may be known as a clay bitusol.

In other instances the disperse phase may be liquid instead of solid, as the case of oil when dispersed in water in the form of an emulsion. Albumen, white of egg, is another colloid distinguished by the fact that it is converted into a jelly, abbreviated "Gel," by heat, not again reconvertible to a sol. This is called an irreversible colloid, whereas gelatine in the form of a gel can be reconverted to a sol, that is to say, is reversible while the solution of such a substance as gum arabic hardly exists in a gel form. The different types of liquid colloids are well represented by these instances, and it appears that they may exist in very different forms.

Particles of the degree of dispersion in which solid disperse colloids exist are not visible under the ordinary microscope but a modification of this instrument, known as the ultra-microscope, has been devised which, in the case of solids of a different degree of refraction from the continuous phase, makes them visible in an active and characteristic state of motion, and serves as a means of determining whether a solid material is so widely dispersed as to be in a colloidal state. This instrument has contributed in a most important degree to our study of the disperse colloids, more particularly of the disperse solid colloids.

As colloids are not readily diffusible through semipermeable membranes, as is the case with crystalline substances in molecular solution, a study of substances in this state may be carried on with interest, as for example, that of the native bitumens, including petroleum. It appears that some of them form colloidal solutions, as determined by the fact that with appropriate solvents, carbon disulphide or benzol, they will not diffuse through a semipermeable membrane into the same solvent while others, on the contrary, of a crystalline character, as for example, paraffine scale, will diffuse from their solution readily. This enables us to differentiate the native bitumens or petroleums into two classes, those consisting of bitumens forming colloidal

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solutions and those which readily diffuse when in molecular solution. Petroleums and their residues and solid or semi-solid bitumens are found in which bitumen exists in both of these states. Different oils can be characterized and differentiated by the relative amount of colloidal and diffusible matter which they contain, on subjecting them to diffusion. That this goes on readily has been determined by adding a certain amount of crystalline paraffine scale or sulphur to an asphaltic colloidal bitumen and subjecting the mixture to diffusion. The crystalline scale or the crystalline sulphur can be separated from the colloidal bitumen in this way and recovered. This will afford a means of studying the character of our native bitumens and petroleums with interesting results. It has been recognized from practical experience that the crystalline petroleums are not of value as a cementing or binding material in the construction of bituminous road surfaces and that, where they are present in asphaltic petroleums or their residuals, the value of the latter is more or less diminished in consequence. As an example of some preliminary data obtained in this way, the following figures will serve:

DIFFUSIBILITY OF ASPHALTS AND PETROLEUM PRODUCTS THROUGH SEMIPERMEABLE MEMBRANES

Sample	Weight of Residue By Diffusion from 1 Gram		Description
	Gr.	%	
1. Bermudez Asphalt 5% paraffine scale	.0433	4.33	Paraffine
2. Bermudez Asphalt 5% sulphur	.0478	4.78	Sulphur
3. Blown oil residue	.039	3.9	Oil & Sulphur
4. Texas residual	.020	2.0	Colorless wax
5. California residual	.017	1.7	Brown wax
6. Mexican residual	.005	.5	Colorless oil
7. Paraffine residual	.0025	.25	Colorless oil
8. Trinidad residual	.000	.0	
9. Bermudez asphalt	.000	.0	
10. Bitumen from Trinidad asphalt	.000	.0	

It appears that there are evident diferences in the character of the various bituminous materials occurring in nature which have been examined by diffusion, and it is a striking fact that the native asphalts from Trinidad and Bermudez are the only forms of bitumen which yield nothing in this manner. This method of study will, when completely worked out, be an interesting means of differentiating the various bitumens which are in use in the construction of pavements and highways.

A still more interesting fact from the point of view of colloidal chemistry is that one of the native asphalts, that from the Island of Trinidad, contains a considerable amount of clay in the disperse solid colloid form, in fact, as a bitusol, that is to say, a colloidal solution of clay in bitumen. Its colloidal nature is demonstrated by the fact that when Trinidad asphalt is dissolved in a solvent such as carbon disulphide or benzol and the solution is allowed to stand for some months, or when sedimentation is accomplished by centrifugal force, it will still be found to contain from 8% to 4% of mineral matter in colloidal solution, as recovered by ignition, which cannot be separated from the bitumen except through what is known as an ultra-filter. This clay is so impalpably fine that it is, therefore, in a colloidal state and remains suspended in the solution indefinitely. It is invisible under the ordinary microscope, but under the ultra-microscope, which makes it possible to detect particles of colloid size, these are seen in the microscopic field in the highly characteristic state of motion which distinguishes disperse solid colloids and is characteristic of the form of matter.

The importance of the presence of colloid clay in Trinidad asphalt is due to its great power of selective adsorption and to the great surface energy developed by the enormous surface area

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of the disperse solid colloid particles. The importance of this in the construction of bituminous highways, especially sheet asphalt pavements, and the great stability which it contributes to the cementing or binding material and to the mass as a whole must be evident, and it is sufficient explanation of the greater satisfaction obtained with surfaces made with bitumen containing colloidal clay.

The formation of colloids by the action of water on the fine material, or even to some extent on the coarser particles of a water-bound macadam road, accounts for the hard crust which results in this form of construction of road surfaces. Colloids, which are always present in different degrees in clays, are also responsible for the cementing of the particles forming the well known sand-clay surface.

In at least one other direction colloid chemistry is of great interest to the engineer: in connection with the setting of Portland cement. If Portland cement is ground in a tube mill for a long time with water, it is found that it is largely converted by the hydration of its components into a material of colloidal gel-form, and in this form it is used for special purposes which it fills with great satisfaction. If Portland cement is made into a mortar with water, the formation of colloids goes on during the setting of the cement while at the same time a certain crystallization of other products of the hydration of the cement takes place in the gel. The colloid imparts hardness to the cement, being converted into a glassy mass, such as that obtained by drying out the gel of silica produced by the action of acid on water-glass. The setting of the cement is, therefore, explained in part by the formation of colloids.

Colloids play important roles in many industrial processes, notably in the preparation of Tungsten filaments for electric lamps, in the ceramic industry, adhesives and glues, dyeing, bleaching, and clearing of liquids by the adsorption of colloids, tanning, the manufacture of soap, brewing, greases for lubricating, and emulsions of various kinds. In fact, it is becoming recognized that colloidal chemistry, regarded from the point of view which now governs our conception of it, is of more general application than has been heretofore imagined.

To those who are interested in the modern conception of colloid chemistry in greater detail than has been given in the preceding pages, reference may be made to an article on this subject by Prof. Wilder D. Bancroft, Harvard '88, in the Journal of Physical Chemistry, 18, 549, Oct. 1914, and as regards its industrial applications to a translation of a small German book by Arndt, entitled "A Popular Treatise on the Colloids in the Industrial Arts"—The Chemical Publishing Company, Easton, Pa. 1914.

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SECTARIAN SOCIETIES AT TECHNOLOGY

Editorial Note:—It should be distinctly understood that undergraduate communications published by this magazine do not necessarily express the editor's views upon the subject in question. Discussions by students, however, presented in a fair, open-minded manner, and of general interest, will usually find space in our columns.

TWO religious societies whose membership and motives are sectarian exist already at Technology. One of these has an enrollment of approximately ten per cent of the student body. The result of the presence of these organizations is that other sectarian bodies are either projected or actually being formed.

Last week I was asked to join a new sectarian society being formed at Technology. I am proud to say that I declined. Below I shall give a few reasons why I believe that students should decline to join sectarian societies and why I consider sectarian organizations a menace to the brotherly spirit of fellowship which we should try to develop at M. I. T.

Sectarian societies breed race feeling. Anyone familiar with the causes of race antagonism knows that segregation is one of the chief causes of race prejudice. Sectarian societies as a form of segregation help race prejudices to flourish. That such a state of affairs is unsatisfactory is shown by the fact that this feeling exists to a certain (but I am glad to say, mild) extent at the Institute.

The members of the sectarian societies at Technology will reply in their defence that they are banded together primarily for social purposes; that religious work or propoganda is not in evidence;—in short, that a certain religion is nothing more than the ticket of admission to the society.

The thinking man will agree that the religion of the individual is an accident dependent upon the religious views of parents, and the sectarian atmosphere which is breathed when the human mind is youngest and most receptive. No more than man has any choice in the selection of the family into which he will be born has he any control over the religious attitude instilled into him! Religion is the result of chance circumstances except where men have changed their original attitude toward things spiritual, or in the very, very, very few cases where men have continued with their "accidental" faith—after having studied various religions—because of honest, sincere conviction that the religious views dictated to them were superior to all others.

Therefore, inasmuch as religion is an accident, is it just to seek social enjoyment solely with those who have had the same religious "beliefs" thrust upon them? Such an unnatural acceptance (certainly not selection!) of associates can be regarded only as bigotry. One deplorable result is that it spells social ostracism for our talented foreign students. The discounting of merit and giving of emphasis to inherited, fortuitous religions is a proceeding which is unpardonable at M. I. T., where are gathered together all races and creeds representing the cream of the manhood of the earth.

Each sectarian organization forces into existence other sectarian organizations. I predict a dozen at Technology within a few years, unless a few judicious steps are now taken.

Therefore, since sectarian societies breed race prejudice, and since only in rare cases is sectarianism not accidental,

(1) I call upon the members of the various religious organizations at Tech-

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nology to show a really "Christian" spirit by letting down the bars of sectarian differences, and throwing open their membership to all races and creeds.

(2) I ask the Faculty and the Institute Committee to show their disapproval of sectarian societies at the Institute by forbidding such organizations to bear the name of Massachusetts Institute of Technology (in any of its forms) and, by refusing to be present at sectarian functions.

RICHARD G. BERGER, M. I. T., '16

P. S. I have written this solely with the idea of suggestion for common welfare, and with no feeling of animosity toward the members of the sectarian organizations at Technology. I hope that it will be received in the friendly spirit in which it is written. R. G. B.

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PHOTOMETRY

By FRANCIS E. CADY, M. I. T., '01
Physicist General Electric Company

IF one were to ask an ordinary storekeeper what the letters "c. p." stand for when written on the label of an incandescent electric lamp, he would probably say that they stand for the word "candle-power." But if he were to be asked further what system of measurement is used in determining this "candle-power" he would probably be at a loss to answer. And yet a measurement of the candle-power in various directions from the lamps in his store might show him how he could very materially improve his lighting arrangement, and this measurement would involve the system referred to which is that branch of physical science called photometry. It is a word far more familiar to those who furnish the means for producing light than to those who use the light. The gas man might seem to be trying to get away from it by rating his gas according to its heating value; the incandescent lamp manufacturer might seem to be trying to get away from it by labelling his lamps in terms of the electric power required to operate them, but the customer who uses gas or lamps for light judges their value by the illumination produced which is measured by means of photometry.

While the subject is not new, in comparison with many other branches of optics, the establishment of the great governmental standardizing bureaus in Germany, France, England, and the United States in the past twenty-five years, together with the large increase in the number and variety of illuminants available in recent times, has focussed attention on the importance of the proper measurement of light and the means for accomplishing it. Today there is so much competition between lamp manufacturers that photometric data are as requisite in exploiting a new product as the knowledge of its cost and energy consumption.

To the uninitiated it might seem possible for a trained observer to measure the intensity or light-giving value of a source by simply looking at it, but unfortunately the eye, while it is extremely sensitive to differences in intensity, is very insensitive when it comes to judging the amount of such differences. On the other hand it is this very property of the eye, i. e. the ability to detect small differences, which enables it to be used as a "zero" instrument and has made possible the present accuracy in photometric work.

Photometry is rather unique in that it involves as a rule only two general laws, the geometrical law, known as the "inverse square law," which states that the variation of the intensity of illumination of a surface is in inverse proportion to the square of the distance of the surface from the luminous source, and the trigonometric law of Lambert known as the "Cosine law," which refers to the variation due to the incidence and emission of the light. The first is rigorously true only where the source of light is a point, but it is found in practice that no appreciable error arises from this fact when suitable precautions are taken. And similarly in the case of the Cosine law it is found that variations

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from it exist in most substances but can be allowed for.

A photometer may be defined as an instrument by means of which the effect of the luminous intensity of one light source may be compared with a similar effect produced by another light source known as a standard. These effects may be in the form of illumination, or in the ability to discriminate detail, or changes in photographic plates, or the change of resistance of a selenium cell, or the so called photo-electric effect, or the excitation of fluorescence, or in some other form in which the action of light is manifested. The great majority of instruments are arranged for a comparison of illuminations.

In view of the relatively small number of different types of photometers in common use at the present time it is surprising to review those which have been devised. Thus, of those based on a comparison of illuminations, there is the earliest known type, that of Bouguer, which has inspired modifications by Foucault, Violle, Harcourt, and Wybauw. There is the "shadow" photometer attributed to Lambert and described by Rumford. There is the Ritchie wedge instrument, the prototype of varieties by Villarceau, Conroy, S. P. Thompson and Starling, Trotter, Lummer and Brodhun, Martens, Wild, Weber, Beckstein, Majorana, Simmance-Abady. The translucent block scheme of Elster, and, independently, of Joly, has been modified by Krüss. The "grease spot" photometer of Bunsen has been improved on by Rüdorff, Hefner-Alteneck, Krüss, Töpler, Leeson.

In the instruments just mentioned, equality of illumination is obtained either by moving the photometer or the sources. In the photometers of Arnoux, Preece and Trotter, Wingen-Krüss, the "Cosine" law is used. The use of diaphragms is involved in the "cat's eye" instrument of Cornu, in Napoli's photometer and that of Crova and in the stellar photometers of Herschel and Steinheil. This principle has also been used by Fizeau, Foucault and Simonoff. The properties of diverging lenses are employed in Ayrton and Perry's dispersion photometer while Mascart used both the latter principles.

The use of an absorbing wedge by Pritchard has been modified by Pickering, Sabine, Gothard, and Spitta. It is a curious fact that instruments in which the movable absorption wedge is used to vary the illumination are quire generally called by astronomers "wedge" photometers, whereas this appellation is used by ordinary photometrists to indicate instruments of the Ritchie type.

Photometers in which the properties of polarized light are used have been devised by Arago, Bernard, Beer, Jamin, Becquerel, Zöllner, Möller, Dubosq or Babinet, Wild, Weber, Martens, and Grosse.

To the above list should be added the various instruments known as illuminometers devised by Weber, Martens, Brodhun, Sharp-Miller, Macbeth.

Visual discrimination or acuity has been made the basis of photometers devised by Celsius, Herschel, Lepinay and Nicati, and Weber. Photometers in which the disappearance of flicker is the criterion of equality have been brought out by Rood, Whitman, Simmance-Abady, Beckstein, Krüss.

In addition to the above there are numerous spectro-photometers, integrating photometers, and photometers utilizing the action of light on various chemicals. But of all instruments the only ones which may be said to be in common use in ordinary photometric

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work are the Bunsen and Lummer-Brodhun types.

Before the advent of the incandescent lamp as a secondary standard of light, the limit of accuracy in photometric measurements was ordinarily considered about two per cent, since that represented the reproducibility of the Hefner standard lamp. The constancy of the carbon filament incandescent lamp when operated under suitable conditions disclosed the possibility of an accuracy of a few tenths of a per cent and enabled the establishment of working standards through which the unit of candle-power could be and is maintained with a high degree of precision.

It is perhaps natural that many interesting and perplexing problems have arisen in photometric work, since it involves not only the use of the sense of sight but the measurement of sources of such widely differing characteristics. One of these problems is the question of the comparison of light sources differing in color. Many attempts and much research have been devoted to an effort to satisfactorily answer the question, what is the difference in candle-power between a green light and a red light? Some very surprising results were found in an attempt to measure the candle-power of the "Neon" tube light, which is a sort of pinkish red in color. Another problem in which it is found that different observers get quite different results is in the comparison of sources with which, when rotating, a flickering illumination is produced on the photometer screen. The photometry of gas lamps is complicated by the necessity of making barometric and hygrometric observations and, in some cases, using a flame standard, stellar photometry is complicated by the small illuminations available and the use of the photographic plate with its accompanying uncertainties.

The application of photometry to the rating of lamps is more often referred to than its application in other lines such as astronomy and photography. The whole question of "magnitude" and all that it involves with respect to the stars depends on photometric observations. In photography the photometer is employed in determining the relative densities of different film deposits and in studying the effect of light filters. Certain forms of pyrometers used for the measurement of high temperatures are merely forms of a photometer and the latter has been used to great advantage in studying radiation and the radiating properties of materials.

The value of the photometer as a tool may be further illustrated by its use in the calibration of electrical instruments such as voltmeters and ammeters. Thus it is known that the candle-power of a carbon lamp changes approximately six times as much as the voltage or current changes. And this is true whether the current is alternating or direct. If, therefore, we determine, using a potentiometer, the candle-power corresponding to a definite value of current or voltage, we can determine when that current or voltage is reproduced, by simply altering one or the other until we get the same candle-power value as before. If the electrical quantity is desired to one-tenth of a per cent, the candle-power need be read to only six-tenths of a per cent and the instrument to be calibrated may be either of the direct or alternating current type.

Many attempts have been made to replace the human eye with some other form of detecting apparatus. The selenium cell and the photo-electric cell have given much promise in this direction, but both are still far from being satisfactory except in very special cases.

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THE TEACHING OF THERMODYNAMICS

V

THE MEAN ENERGETIC CONDITION, TEMPERATURE, WORK-PERFORMANCE, AND THE RADIAL COMPONENT

Cosmic Equilibrium

By PROFESSOR SIDNEY ARMOR REEVE, M. E.

In the opposite direction temperature knows no such a definite limit, nor any limit at all except the difficulty of contributing further temperature to a very hot body. For there are only two well-known ways of increasing a body's temperature, viz: (1) Thermal conduction, which calls for some external source of heat which is hotter still than the very hot body; or (2) compression, which calls for an external source of work of a higher pressure than the very hot body—and very hot bodies, other things being equal, have very high expansive pressures. Or, if electrical or chemical means be sought for heating the very hot body, similar obstacles appear.

But, as temperatures increase, there does appear a fairly fixed limit to increase of entropy, or zero of solidity. At this extreme of gaseousness temperatures vary widely, and entropy little, just as at the opposite extreme of solidity entropies vary widely and temperatures little. Of this, more later.

Again, returning to the representative Newtonian system, there must exist a mechanical equilibrium, among a large community of mass-pairs, tending toward equality of radial and tangential motions, although such equality could never be reached by all at once. In this the tendency would be toward a *parabolic* form of orbit, as median between elliptic and hyperbolic. But in every mass-pair of such a community, however widely departed from this median in either direction, there must always be present some of each component motion, radial and tangential.

In this these two components are again parallel with the liquid and gaseous states respectively. For, whereas it was formerly taught that a solid was all solid and a gas all gas, absolutely, now it is known that virtually all solids contain some liquid and exert some vapor-pressure, and that all gases are somewhat solid, or viscous, or "imperfect." The thermo-mechanical interpretation of this is that in all solids the majority of molecular orbits are of very low eccentricity—almost circular—but that a few are parabolic or hyperbolic. Conversely, in all gases the majority of orbits are hyperbolic, a few always remaining elliptic, however. For the prime difference between the three physical states is purely a thermal one. Virtually all known substances can be converted into any of the three by the supply or abstraction of heat.

Again, this parallel holds as to *relative facility for thermal conduction or work-performance.* In systems having orbits of low eccentricity, with little radial motion, it is natural to expect unusual susceptibility to tangential motion contributed from without; and this is just what is characteristic of the solids, that they conduct heat easily, exert friction and impact naturally, and are intractable as to adiabatic

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work-performance. In the gases, on the other hand, as is natural with systems having high eccentricities of orbit and much radial (with little tangential) motion, just the opposite is characteristic: they conduct heat poorly, exert little impact or friction, but are facile in the performance or absorption of *work*.

Before proceeding further with general arguments it were well to investigate further the mathematical aspect of this contrast between radial and tangential motions and energies respectively. If expressions for the tangential energy be deduced from the equations already given there results *Radial Energy*

(potential) (kinetic)

$$E_r = 2cM_1M_2\frac{e}{D} = 2M_1M_2\frac{U_t^2}{M_1+M_2}e,$$

in which Ut is the tangential velocity in the mean energetic condition. The mass-factor is, as always, the *product* of the two masses, and their sum appears as a denominator in the kinetic form.

The radial or communicative or work-performing energy, then, is *proportional to the eccentricity*, when the volume or tangential motion remains constant. Since e is the ratio of radial to tangential velocity, it might seem that it ought to appear in this expression as a square; but it does not.

For the tangential "energy," however, no expression is deducible. This is to be expected, for the tangential motion is not capable of transferring itself to any other system, nor of "overcoming resistance," nor of performing external work. Hence it is not "energy" at all, according to any of the criterions of energy. If anything, it is matter.

Here again is one of the ideas of the utmost importance which is very loosely taught at present. What is energy? It is quite commonly assumed that motion of mass is energy. But it is not so, necessarily. It is not energy unless it can overcome resistance, and several conditions besides motion must be fulfilled before motion is energy. Thus, this tangential or circular motion is not energy. Latent heat is not energy, and we have seen that latent heat is this tangential component, in any mechanical theory of heat. A *relationship* between latent heat of 212° and a condenser of 100° constitutes energy, it is true; but this is a temperature or radial relationship. The latent heat, of itself, is not energy, as our most common-sense engineering experience teaches. Yet latent heat is motion.

If the last equation be divided by e there results an expression containing only tangential motion or, in the potential form, *volume*, its equivalent. There is no basis for calling this the equation for tangential energy, for there is no such thing; but it may fairly be called the mathematical expression for *matter*. This is said chiefly to show how loose are our usual definitions of energy, etc., even while still in the well-known field of mechanics. When the motion is purely circular no external system can take cognizance of it, except as a unit. We are cognizant of it only by its external reactions—by its rigidity (by centrifugal force) against compression if it be squeezed, by its tenacity (by gravitational force) against extension if it be pulled. But both of these effects are manifested by the *pair*, not by either individual mass, and the pair appears as a unit of solid *matter*. Another like pair, whirling in opposite direction, can develop, in reaction with it, *entropy*, but not energy. *En-*

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ergy implies not only the presence of *two* masses and *radial* motion between them, if the energy be internal, but a velocity-contrast between two such radial motions—as between boiler and condenser temperature—if the energy is to be external.

This contrast between tangential and radial components of motion at the mean energetic position, then, develops into a natural Newtonian explanation of a contrast which runs through all physical phenomena. It is therefore of the utmost importance that it be presented to the student early, often, and prominently, as soon as he enters upon the study of energetic phenomena. This contrast is that of matter with space—a contrast dating back in life to the infant's first learning not to bump itself against solids—that between elasticity and inelasticity, between work and heat, between temperature and entropy—even if we go on further and include the electrical equivalents, potential versus resistance, voltage contrasted with current, electricity itself as antithetical with heat. All these direct contrasts are now connected with each other by far too many intricate links of scientific experience for them to be presented to the student any longer as disconnected haphazard facts.

These two contrasted aspects of nature are displayed below in parallel columns. They are not offered as interesting analogies. In order for them to be only that, one must root out from the history of science all the work proving the identity of thermal and mechanical forms of energy, starting with Davy and Count Rumford a century ago and including Carnot, Clausius, Joule, and Lord Kelvin more recently. One must be careful also to discard all our views which are unconsciously based upon their work, and to discard also all belief in identity between those other forms of energy between which have been proven, in manifold ways, the same basis for such belief as underlies our common characterization of heat as "a mode of motion," viz: mutual transformability and quantivalence. This is a feat which no responsible teacher dares to undertake; yet if this is not done the several items in the following columns *must* be accepted as identical, and not merely analogous, in their physical constitution.

NATURE'S CONTRASTED DUALITY

NEWTONIAN MECHANICAL ENERGY

I.	II.
MATTER, "occupying Space."	SPACE unoccupied, or Geometric Space.
INELASTICITY	ELASTICITY.
The Universal DISSIPATOR of Force in Impact & Friction.	The only known TRANSMITTER of Force.
TANGENTIAL Motion of a Mass-pair.	RADIAL Motion of a Mass-pair.
Independence of ECCENTRICITY of Orbit.	PROPORTIONALITY to ECCENTRICITY of Orbit.
Passively RESISTANT to the greatest Forces, but itself INACTIVE.	ACTIVELY EXPANSIVE, but Yielding to the Slightest Force.
The MASS-function.	The SPACE- or MOTION-function.

THERMAL ENERGY

TRUE HEAT—Latent Heat.	TRUE "WORK"
ENTROPY	TEMPERATURE
CONDUCTIVITY	INSULATION
SOLIDITY	GASEOUSNESS, or active Expansivity
RIGIDITY	FLUIDITY

ELECTRICAL ENERGY

CURRENT, in Kinetic Electricity.	POTENTIAL
CHARGE, in Static Electricity.	POTENTIAL

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CHEMICAL ENERGY

ATOMIC or MOLECULAR MASS	DISSOCIATION, or Spacial Separation.

RADIANT ENERGY

OPACITY	TRANSLUCENCE

It is not meant by the above that all these terms are synonymous, in either column, else we should have found no separate use for them. It does mean that all of them rest upon physical identity, and that all, either positively or else in the greatest probability, are contrasted with their mates in features closely related to circular and radial motion respectively.

Every natural phenomenon, it should be taught the student, embodies *both* factors of some one or more of these contrasted pairs. Neither factor ever exists alone, nor is it ever zero. We know of no matter not occupying space, nor of any space devoid of matter. We know of no matter without energy, nor energy ever separated from matter. We know no perfectly inelastic solids, nor any "perfect" elastic non-viscous gases. We know of no locality of zero pressure, nor any matter of zero volume, or zero temperature. We know of no possibility of reducing any of nature's attributes to zero, nor of expanding any to infinity. We know only *contrasts* between things, in all these lines situated unusually on one side of the mean, with things on the other side of that mean.

In every case TWO factors appear as a PRODUCT—mass times space or motion, volume times pressure, temperature times entropy, current times voltage, etc.—to form the whole which we call energy and which is conserved. By chance environment either of these two factors may become very small or very large, but only by the other factor becoming the opposite. Under no conceivable natural circumstances can either factor ever be reduced to zero or expanded to infinity. Their product must remain finite and determinate. Thus it is inconceivable that any gas should be expansible so far that its pressure becomes zero, or compressible so far that its volume becomes zero. For to talk of "infinities" in nature, as necessary to explain "zeroes," is to lose all naturalness and all meaning. An infinity is greater, just as a zero is less, than any assignable physical quantity; and in physics we study only physical quantities.

In this same way tangential and radial components are present in all mechanical motion, whether molecular or mundane or stellar. The eccentricity of orbit may vary from near zero to very great indeed; but it may never quite attain to either purely circular or truly rectilinear motion Thus when a weight, such as a foundry drop, falls, the present teaching is that it falls directly toward the center of the earth in a straight line, that its energy is measured by the formula W x H, and that when it strikes the ground "all" of its energy is converted into heat. This is near enough the truth for foundry-yard work, but for real education as to mechanics, and especially thermodynamics, it is crass error.

For the foundry-drop, when released, really embarks upon an elliptic orbit about its common center of mass with the earth, very near the earth's center. If we imagine the solid earth tunneled to form a free pathway for the drop, this ellipse, instead of being a straight radius of the earth, would spread to a conjugate diameter, at the widest, of over 100 miles! When opposite the earth's center its mean energetic condition would show some

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55 millions times the energy developed in the factory-yard.

The fact that the solidity of the earth prevents this full fund of energy, which exists potentially within the situation all the time, from ever being manifested, is a real and important fact, but it is also an accidental one. The foundry-drop will act in Newtonian fashion until its further action is prevented by the earth's solidity. By that time only an insignificant fraction of its inherent mechanical energy will have been converted into motion, and finally into heat by collision with the earth. The bulk of the remainder cannot conceivaby be converted into heat.

There is no more erroneous statement, among all the mis-statements taught the poor students, than that "work can become converted into heat, but heat cannot all be converted into work." When we mention heat we include *all* the internal energy of the particles of the body, but when we mention work, we refer only to a very small portion, the terrestrial portion, of the mechanical energy inherent in the body. The statement is not in any way a fair one, and consequently is one leading to wrong conclusions. Every and any form of energy can be transformed into any and every other form, in part. All forms are one, at base. That is the most important fact to be taught in energetics. But with it should always be taught that *only a portion* of each form can be so transformed. It is never possible to transform all.

COSMIC EQUILBRIUM

By arguments too long for more than mention here it can be shown that the accidents of natural environment tend to maintain equality of radial and tangential components of orbit, as in the parabola. As any orbit happens to attain an excess of radial motion, or to approach rectilinear motion, the chances of its loss of that excess to some other system increase; and as it chances into a deficit of radial motion its chances for making good that deficit by gravitation also increase. The law of equipartition of energy in stable equilibrium applies here.

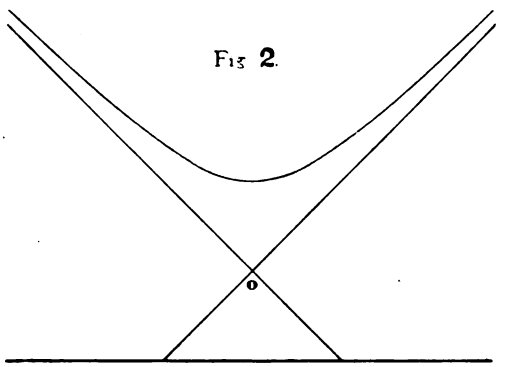

Fig 2.

This universal principle of EQUILIBRIUM is one of the most important for the student's education derivable from a study of the energetic sciences. As a first illustration of it Fig. 2 is appended. It shows an ordinary equilateral hyperbola with its axes canted to an angle of 45°. In this position it best furnishes the imagination with a picture of the universal tendency of all phenomena to gravitate into medial conditions, in which conditions they can never stay when arrived.

Let Fig. 2 represent the path of a frictionless pendulum suspended vertically above the origin; or let it be the cross-section of a frictionless inclined trough down which a ball is rolling. In either case, if lateral motion be once supposed to exist, it will always continue; yet the ball will always seek the central position. But whenever it

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gets there it has acquired a countervailing tendency, which we call kinetic energy, to leave the central position—which tendency it loses as it departs from the center.

This action is typical of all energetic phenomena. Let Fig. 2 represent the pressure-volume condition of any gas, one axis measuring pressure and the other volume. Their product being a constant, the curve is the locus of all possible conditions for the gas. No pressure can be so great as to make its volume zero, nor any volume so great that its pressure is zero. Moreover, as its volume increases unusually the chances increase for its happening to be compressed by external pressures, because its own pressure is below par; and conversely, the smaller its volume the better the chances for its expansion, owing to its own pressure being greater than external opposing pressures. Thus it tends always to assume a medial position.

When this position is attained there exists in the gas itself no inertia, to carry it out again; but the chances are that its environment is solid, and that in these solids it has set up motion which will carry the condition again away from medial. In this statement reference is had chiefly to cosmic conditions; but even in engineering the common action of pistons, fly wheels, etc., is in this direction, and in the old free-piston gas engine occurs a most useful application of the idea.

We have already examined the tendency of eccentricity of orbit to maintain the medial value unity, as in the parabola. Other features of mechanical energy also show the same stability of equilibrium. Space of separation is one. As mass-portions gravitate too closely they develop velocities which tend to separate them again. As they separate unusually they lose the separative tendency, and they also increase their chances of approaching some other system of mass-portions.

Another and most important illustration of stability is the mass-factor itself. This, it was pointed out, could vary while the total mass remained constant. But this variation occurs in stable equilibrium. If, in Fig. 2, one axis represents n, the number of equal parts into which the total mass is divided, while the other axis represents the mass-factor X, the curve represents closely their mathematical relationship already given; that is to say, both curves are asymptotic to their axes, although the equation for the mass-factor curve is not quite the same as that of Fig. 2. Further, the medial relationship of n to X occurs when the total mass consists of two equal mass-portions. When n becomes less than 2, it means that the system consists of one major portion and a smaller portion satellitic to it, as when a foundry-drop is split off from the earth. Such a system is unusually solid and inelastic. Its chances for collision and impact are greater than usual, and collision will increase the value of n by fracturing the mass-portions. Conversely, when n is greater than 2 the system is unusually composed of space, and is comparatively elastic. The chances are thereby increased for its giving up some energy to external systems and consolidating by gentle gravitation.

But these factors of mechanical energy have been identified with the thermal factors, temperature and entropy. If this be true, heat should also show the same stable equilibrium. To show that this is true a thermal diagram, Fig. 3, is shown. Its axes measure entropy and temperature respectively. Its curve is not the true unbroken hy-

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perbola of Fig. 2, but a logarithmic curve, broken thrice by gaps of instability. Nevertheless the curve of Fig. 3 is of the same physical type as Fig. 2, and also as that of the mass-factor, in that it is asymptotic to both axes.

Fig. 3 is the ordinary entropy-temperature diagram for steam, but carried to comparative completeness. It displays the entire course of H_2O, as a carrier of heat and work, from the condition of a very cold solid (ice) at the left to that of dissociated gases at the upper right. The axis OY is the axis of absolute temperature, the origin showing the absolute zero point. The axis OX is that of entropy. The usual axes for both these quantities, according to the steam-tables, however, are quite differently located from these. TT is the ordinary steam-table axis of temperature and ZZ that of entropy (for the Fahrenheit scale). The zero point

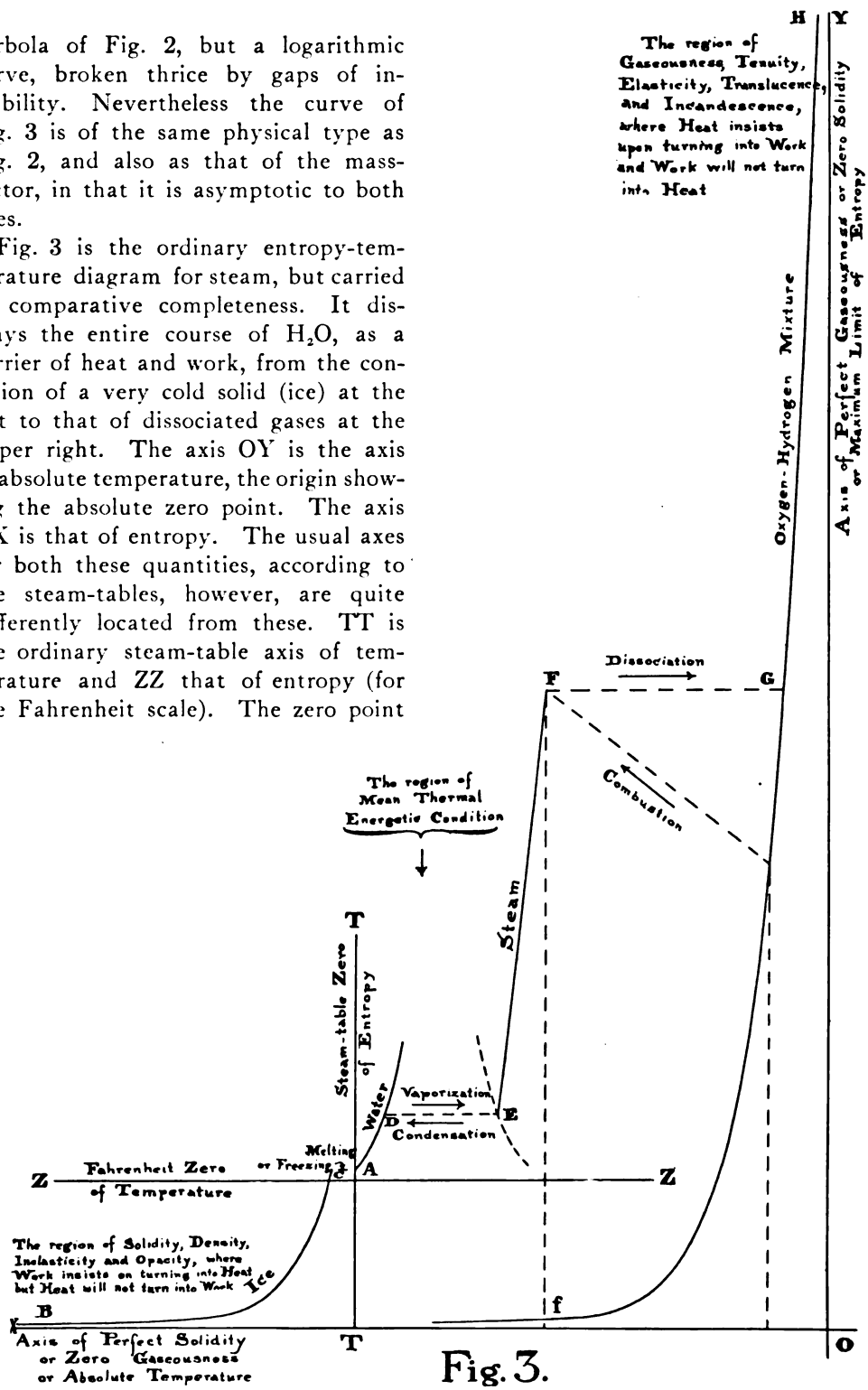

Fig. 3.

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of heat, according to the arbitrary standard of the steam-table, is at A.

Starting at B with ice of the lowest known temperature, let impact and friction be applied. Conducted or radiant heat, chemical energy of combustion, or heat of electrical resistance will all have the same effect; but for clarity of understanding of heat the argument will be confined to impact and friction, which the average student understands if he understands anything, while these other energy-forms he does not understand at all.

This impact and friction will have marked effect, at first, because of the brittle hardness of the solid; and with most other substances than ice it would have a still more marked effect. Continued application will warm the ice through all the degrees of temperature up to C, its melting-point. At first because of the very low value for T in the expression for entropy, increase in entropy will absorb almost all the progress, the curve being almost parallel with the axis OX. Indeed, to reach the lowest temperatures now attainable the curve would have to be extended much further to the left than as drawn if to scale. But as the absolute temperature becomes greater the rise of the curve becomes more rapid.

At C occurs the first point of instability, the melting-point. From A to D is the isomorphic curve for water, ending at the boiling-point in a second condition of instability, vaporization DE. From E to F is the stable isomorphic process of superheating steam, ending at F in the third condition of instability, dissociation FG. Beyond G rises the final stable isomorphic curve GH for the dissociated gases, hydrogen and oxygen. So far as we now know, there is no further condition of unstable isothermal change; but the increase in specific heats of the elementary gases at these higher temperatures may indicate the approach of some such a phenomenon, at temperatures not yet reached.

In all this curve, which is typical of all known substances except helium, which has not yet been solidified, the point of prime importance is that it is everywhere convex toward the two axes, except in the instable gaps which interrupt the true curve; and even these do not negative the general fact. In other words, no amount of heating can ever bring the gases to the condition where their temperatures rise adiabatically, parallel with OY; in which case they must have lost all viscosity, all sensibility to impact and friction, and be "perfect." On the other hand, no imaginable degree of cooling can ever either reduce their temperature to absolute zero, bringing the curve into the axis OX; nor can the removal of any conceivable degree of entropy, by any imaginable process, ever bring the curve into parallelism with this axis, indicating that the substance had no more temperature to be lost.

Professor Callendar, in his remarkable address as President of the British Association in 1912, speaks of the "awkward" habit of entropy becoming infinite at very low temperatures. But if entropy did not do this, this fact would itself constitute a single exception to the entire class of factors of energy, *all* of which approach infinity as their mates approach zero. Such an exception would be far more awkward to explain than is the customary fact. And this points another moral, viz: That at very low temperatures the prime variable is entropy, rather than temperature, and that exact measurements would be very much easier if such substances were observed in terms of some satisfactory scale of *solidity* (which

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is the opposite or negative of entropy), instead of in terms of temperature.

The next point to be observed in Fig. 3 is that it portrays a state of cosmic equilibrium. At the lower left lies the region of low temperature, of high solidity or rigidity, usually also of inelasticity and opacity. Here kinetic work and radiant energy insist upon turning into heat, while what heat there is there can with difficulty be gotten to change partly into work, if at all. Chemical combinations, if possible, are usually exothermic. All processes tend to return the substance toward the mean thermal conditions shown in the center of the diagram.

At the opposite side of Fig. 3 the exact opposite of all these tendencies is observed. This is the region of gaseousness, of tenuity, of fluidity, of expansiveness, of elasticity, of translucence, and of incandescence. Here work refuses further to turn into heat (except with difficulty), because impact, friction, and viscosity are almost completely absent. Radiant energies are absorbed with difficulty, because of translucence. On the other hand, because of the expansiveness, heat tends to turn into work very easily and with maximum efficiency. All processes thus tend to return the substance toward the mean thermal conditions of the central portion of the diagram.

Even in simple thermal conduction this same stability is observable. It is not merely that as a substance gets very cold the chances increase that its neighbors are hotter and will contribute heat to it, while, as it becomes unusually hot, the chances increase that it will find its neighbors cooler and will lose heat to them. The prime fact is that the solids are, as a rule, the best thermal conductors, while the gases are the poorest.

Now purely experimental science ha already long passed the point of regarding either solidity or liquidity or gaseousness as an absolutely exclusive condition. Liquids and gases are alike, except in the mere degree of vapor-tension and in the surface-tension of liquids. Professor Soddy, in his "Matter and Energy," says:

> "The extension of the kinetic theory to liquids was one of the great advances of the closing decades of the last century."*

All solids exhibit some vapor-tension and are now regarded as embodying some liquid and some gas. Minute particles of ice have been detected in steam, while the persistence of water in the region of superheated steam is one of the most familiar obstacles to an ultimately satisfactory steam-table practice. In other words, the refusal of the curve of Fig. 3 either to coincide with or to become parallel with the axis of solidity OX is because the substance is not yet a "perfect" solid—by which we mean that not all of it is solid—and can never conceivably become one. Conversely, the curve never reaches nor parallels the axis of temperature or fluidity OY because the substance is not yet a "perfect" gas—that is, it is not all of it gaseous—and can never conceivably become so.

All of this agrees perfectly with the general concept of molecular energy as identical with mechanical energy, as defined by the Kepler-Newton theory of orbits. Solidity, density, rigidity, opacity, etc., mean *low eccentricity*, approaching *circularity*, of orbit, coupled with small radius of mean energetic condition and very high tangential

*The essential differences between the liquid and gaseous states are confined solely to an exceedingly thin skin at the boundary or surface of the liquid. *Inside* the liquid an unhampered independent motion of the molecules, moving by virtue of their own kinetic energy and not restricted in any way except by their incessant mutual encounters, is going on exactly the same as in gases.

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velocity to balance it. But because the solidity is never quite complete nor the temperature ever absolutely zero, there is always some slight eccentricity of motion, some slight radial energy.

Gaseousness, tenuity, fluidity, expansiveness, elasticity, translucence, incandescence, etc., on the other hand, mean *high eccentricity* of orbit, or hyperbolic path, approaching radial straight-line motion. But because the gaseousness, etc., is never quite perfect, there always remains some slight tangential component of motion, and rectilinear motion is never quite reached.

There is still a third alternative extreme of physical state which falls within these lines, having its corresponding form of orbit. This is matter such as might be represented in the region lying nearer the origin of Fig. 3 than the curve. This region cannot be reached from the curve directly, by mere impact and friction, nor by thermal conduction. If we take the point *f* as illustrative of this region, its physical condition proves to be attainable either by (1) the dissociation of the H_2O into its gases and then their separate cooling, or (2) by *adiabatic expansion of steam from F.* This does not mean that these two processes result in the same physical stuff, but that their thermal conditions are at least comparable, in mechanical form of motion. Indeed, it seems to mean that traverse of the field of Fig. 3 normal to the H_2O-curve signifies *chemical* transition; for each different chemical substance will possess a different thermal curve, similar to that of H_2O in form, but nearer to or further from the asymptotes.

As to the physical state represented by this corner of the diagram, whereas the left-hand extremity represented *solids*, having nearly circular motion of very small radius, and the right-hand upper extremity the *gases*, having nearly rectilinear motion of wide scope, this condition near the origin, resulting from the adiabatic expansion of a heated gas, can be conceived mechanically only as molecular motion almost circular in form—or at least, of much lower eccentricity than it had before expansion—but of relatively large radius and low tangential velocity. For the abstraction of work adiabatically can reduce only the radial component, reducing the eccentricity; at the same time the volume increases, a thing which would naturally happen to a pair revolving in hyperbolic orbit if external pressure were reduced. Again, internal equilibrium determines that when the mean energetic distance increases, the tangential velocity must decrease.

This condition of matter is of threefold interest. First, to the engineer, it represents low-pressure steam, etc. Second, it represents to the astronomer the energetic aspect of the solid meteoritic particles of interstellar space. Third, to the astrophysicist, it may represent similarly the nebular gases of extreme tenuity. In general, it represents the combination of very low pressure and temperature with very great volume. Without attempting to assign to it a "fifth physical state," it may be noted that these conditions are the opposite extreme from "radiant" matter, which moves in almost straight lines.

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She—"Doesn't Harold look swell in his track suit?"

He—"Oh I don't know,—I would rather say, 'knobby.'" —Siren.

PINE

Pine is the name of a wood with a rather soft and yielding grain. To the writer, this word has gained a great significance in describing the sad things of life. Coffins for the poor and indigent must always be made of plain pine, never ash, hickory, or sassafras. The workman out of a job must always scold his wife across a pine table, stamp his boots on a pine floor, and hang his hat on a nail in a pine partition. The hungry baby who cries for milk must always have a pine soap box serve for a cradle. If the wife gets a divorce she will pack her belongings in a plain pine box. That leaves the unhappy husband alone to pine away his evenings by watching the glowing embers of a pine fire while he lights his pipe,—not with a pocket lighter,—but a common pine match.

—Siren.

ASLOBS FABLES

Once there was a horse. It was a fire horse. It would come when the bell would ring. The horse got rather aged. The firemen sold the horse. They sold the horse to a man who had a girl. The man took the girl out driving one day. While the man and the girl were out of the buggy picking orchids, a bell rang eight miles away. The horse went to the bell. The girl went out in the middle of the road and rung her hands. The man went out in the middle of the road and rung his hands. The horse came back.—Froth.

A LITTLE BIT FOGGY

Same old time, scene, and place—Enter the two regular funny guys.

First R. F. G.—Got any cigarettes?

Second R. F. G.—Nope; they killed brother and put father in the asylum.

First R. F. G.—How's that?

Second R. F. G—Smoked too many.

First R. F. G.—That's nothing, my father and brother went into the packing industry and at the end of the year had 100,000 hams on their hands.

Second R. F. G.—How's that?

First R. F. G.—Smoked too many.

(Editor's Note:—If this is not quite clear, it's probably because you "smoked too many.")—Awgwan.

Fond Mother—Bobbie, come here. I have something awfully nice to tell you."

Bobbie (age six)—"Aw — I don't care. I know what it is. Big brother's home from college."

F. M.—"Why Bobbie, how could you guess?"

B——e—"My bank don't rattle any more."—Awgwan.

"How much is nine times thirteen?"

"A hundred and seventeen; can't you do that?"

"Eventually, of course, but fools multiply rapidly."—Cornell Widow.

AND HE GOT IT

Fred—"How did you get that black eye?"

Rick—"Taking your advice about ordering that new drink at the soda fountain."

Fred—"Did you ask for a nut sundae?"

Rick—"Well, I said, 'give me a sundae, nut.'"—Siren.

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A Magazine devoted to the interests of the Massachusetts Institute of Technology--The Official Organ of the Association of Harvard Engineers

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Forms close the 28th of the month immediately preceding date of publication. Material specially arranged for may be received up to the fifth day following.

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KEEP TO THE RIGHT

CUSTOMS at our various colleges and universities differ so widely that they often fail to impress us as being real conventionalities. The student at a college sees only his routine and habits; and he is, in general, utterly ignorant of the prevailing practices at other schools. The customs at any school are too numerous to mention if there be anything like uniformity of action in the institution; but someone has noticed that some such customs exist at M. I. T.

An instance was called to our attention the other day which is worthy of consideration. Following several Senior classes in 6 Lowell, the freshmen pile into the room in a manner most disrespectful to their upper classmen. Not only do they deliberately attempt to fill the room before the Seniors have a chance to escape their veritable mob violence, but in rushing into the room and up the narrow stairs, they violate the fundamental traffic rules that even our least educated townsmen have learned to observe.

It is a fact, not generally known, however, that Ann Arbor students have formed the habit of choosing the left hand side when passing each other on the campus. When one of the co-eds with her escort is on the walk, the fellows in passing show her respect by stepping off the sidewalk entirely if at that point the path be at all narrow. Furthermore the men always tip their hats to members of the Faculty and Board of Regents. At other colleges, still other customs prevail. Students of an engineering school in Cleveland step aside and usually off the walk entirely, to allow Faculty members to pass,—the rule is with one or two exceptions invariable in the many schools and universities in Ohio and other middle-western states. Students at the University of Chicago very seldom pass each other if alone, even if not acquainted, but stop to exchange greetings, perhaps only a word or two, whether or not they have undergone the formality of an introduction. A spirit of fellowship reigns at Chicago making it possible for any two members of the university to recognize each other without the fear of being mutually snubbed. At Harvard it has been noted that undergraduates very seldom look up when passing each other in the Yard. At Columbia, it is said that the number of students is so great that there is very little chance of two friends meeting outside the classrooms.

In the Institute of Technology it is a peculiar fact that the students tend to keep toward the inside when walking by the buildings, or toward the left when going through the aisles and corridors; a practice which makes for continual confusion, inconsistent with the general tendency toward organization, system, and order.

So it is desirable that freshmen, especially, undertake to learn the first traffic law. Keep to the right. It may be difficult at first, since freshmen at the Institute have so many diverging ideas to assimilate; but once the custom finds root, it will continue to exist,—much the same as the custom which have rooted themselves in the student life at other colleges,—as true conventionalities.

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ANNUAL DINNER OF THE ASSOCIATION OF HARVARD ENGINEERS AND THE HARVARD ENGINEERING SOCIETY

The Annual Dinner of the Association of Harvard Engineers and the Harvard Engineering Society was held at the Harvard Union on Saturday evening, March twentieth, President Clemens Herschel, of the Association presiding. Dr. Alexander C. Humphreys, President of the Stevens Institute of Brooklyn, spoke at some length and most interestingly on the subject of Regulation of Public Service Corporations, and Professor George H. Parker, of the Zoological Department of Harvard University, described with the aid of lantern slides, life of the fur seal herd on the Pribilof Islands, and his experiences as a member of a commission appointed by the United States Government to make an official count of the herd.

Pres. P. S. Donnell of the Harvard Engineering Society and Editor-in-Chief John R. Tuttle of the Harvard Engineering Journal, spoke on the work of their respective organizations.

The following guests and members were present:

Guests:

President Humphreys of Stevens Institute
G. H. Parker, 1887

1860
Clemens Herschel

1876
A. F. Clarke

1882
C. V. Holman

1885
Henry Bartlett

1887
L. J. Johnson
W. F. Atwood

1890
A. F. Brown
S. H. Thorndike

1892
F. L. Kennedy
L. S. Marks

1894
H. J. Hughes

1895
J. F. Vaughan

1896
Francis Mason

1898
J. A. Butler
F. V. Edgell
J. H. Libbey

1900
A. E. Norton

1901
C. H. Dutton

1904
D. L. Furness

1906
H. K. Alden
F. R. Pleasonton
H. U. Ransom

1907
W. K. Cabot

1908
E. N. Hutchins

1910
R. W. Coburn
M. R. Welfard

1911
F. P. Donovan
K. R. Garland
H. H. R. Spofford

1912
L. N. Clinton

1914
Leslie Clyde
L. K. Harlow
E. A. Roberts
E. S. Schumann
L. W. Weed

1915 (Harvard Engineering Society)
(Graduate Students)
W. C. Atwater
W. B. Clarkson
P. S. Donnell
A. B. Gardner
A. P. Gradolph
A. Y. Hodgdon
C. E. Rogers
J. R. Tuttle

1915
M. L. Wiener

Holders of Honorary Degrees
H. L. Abbott, LL. D. 1886
A. E. Kennelly, A. M. 1906
W. H. Burr, Columbia Univ.
C. A. Adams, Harvard Univ.
G. C. Whipple, Harvard Univ.

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HARVARD GRADUATE NOTES

ALLAN Vinal Garratt, '79, Ashland, Mass., is chief engineer and general manager of the Lombard Governor Company, which builds governors for water turbines, especially hydro-electric installations.

Charles V. Holman, '82, is president and managing director of the Caribou Gold Mines, a holding corporation developing gold mines in Nova Scotia. His home address is Holman Oaks, Rockland, Me.

Alfred C. Lane, '83, had a paper on "Mine Water Composition, an index to the course of ore bearing currents," in Economic Geology last year.

Wisner Martin, '90, announces the formation of a partnership with William J. Freethy under the name of Martin and Freethy, Architects, 141 Milk Street, Boston, Mass.

Joseph Leiter, '91, reports his new address as follows: Dupont Circle, Washington, D. C.

Austin B. Fletcher, '93, Forum Building, Sacramento, California, is engaged in the construction of a system of State Highways comprising 3000 miles, under a special bond issue of eighteen million dollars.

Louis Christian Mullgardt, '93, architect, of San Francisco, is a member of the Architectural Commission of the Panama Pacific International Exposition.

John Pierce Fox, '94, 55 West 44th Street, New York City, is a Transit Expert to the Committee on City Plan of the Board of Estimate and Apportionment. He has recently been appointed Chairman of the Committee on Streets of the City Club of New York. He is also a member of the Transit and City Planning Committees of the same club.

Francis E. Frothingham, '94, 60 State Street, Boston, Mass., is Engineer with Perry, Coffin, and Burr, bond merchants in mortgage bonds of public service corporations.

George L. Smith, '95, 20 Central Street, Boston, Mass., is engaged in designing subway entrances for the Boston Transit Commission. He is also making a special study of farm buildings and practicing architecture at the above address.

Otis Converse White, '96, 15 Haviland Street, Worcester, Mass., is a manufacturer of electrical appliances and interested in the study and practice of wireless telegraphy.

Langdon Pearse, H—'99, M. I. T.—'01, 910 South Michigan Avenue, Chicago, Ill., is division engineer of the Sanitary District of Chicago, in charge of all sanitary and sewage work. He is a consulting engineer with S. A. Greeley, '03, at Decatur, Ill.

Arthur L. Dean, '00, has left the Sheffield Scientific School to become President of the College of Hawaii, Honolulu, H. T., which offers courses in civil and mechanical engineering.

Stanley F. Morse, '06, Tucson, Arizona, is superintendent, agricultural extension service, University of Arizona, College of Agriculture.

Miles Augustus Libby, '06, Lieutenant, U. S. Navy, care of Navy Department, Washington, D. C., is at present assigned to the U. S. S. Texas, as electrical officer.

Theodore S. Kenyon, '11, LL. B., Columbia, '14, editor of the Columbia Law Review, 1912-14, is now practicing patent law with Kenyon and Kenyon, 61 Broadway, New York City.

Arthur L. Kimball, Jr., M. E. E. '14, 110 E. 29th Street, New York City, is assistant engineer in Motive Power, Dept. of the Interborough Rapid Transit Co.

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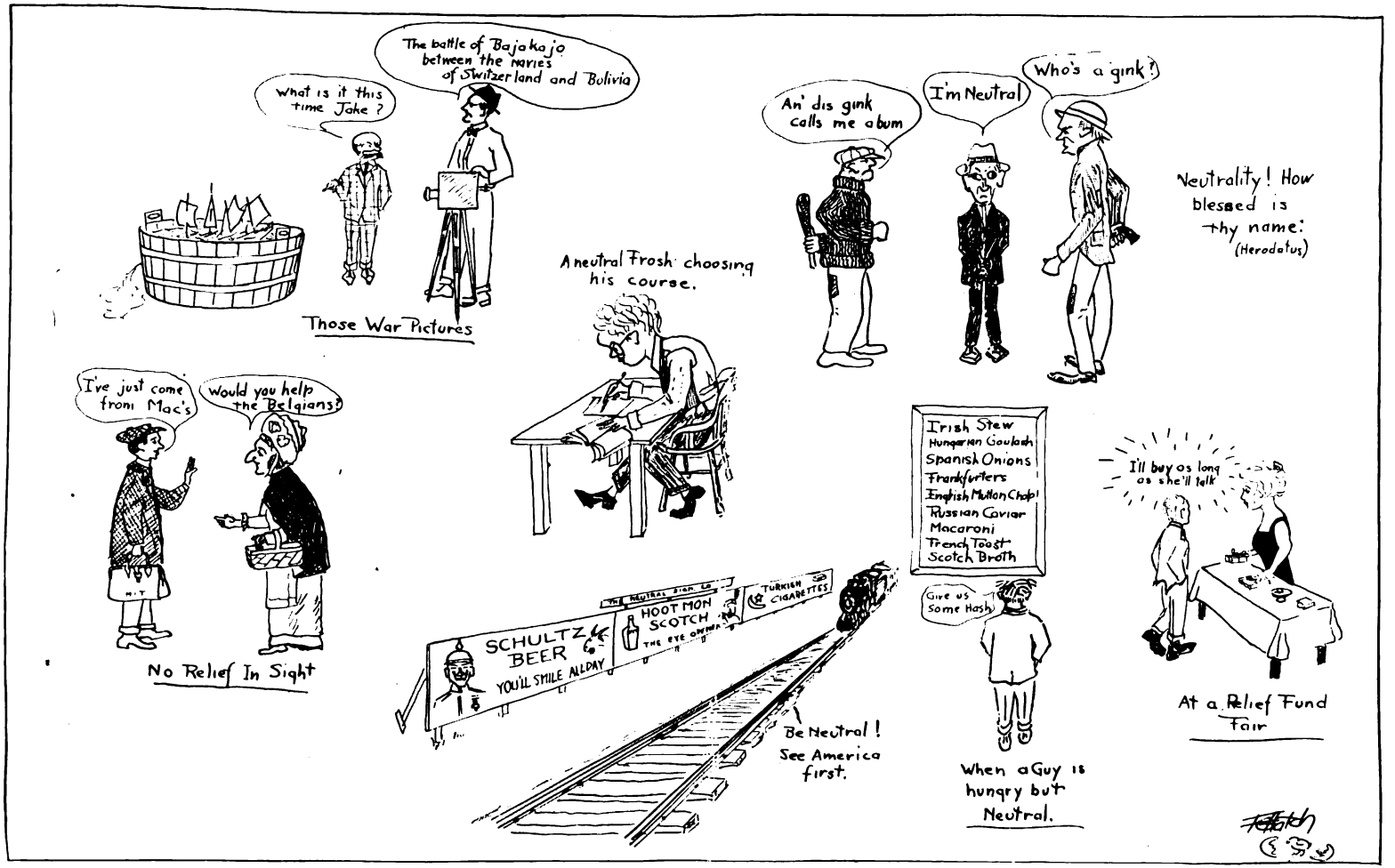

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LOCAL COLOR

We publish two kinds of jokes: jokes on professors and jokes by professors.

AND HOW ABOUT THOSE WHO HAVEN'T?

Professor F. J. Moore: From now on the work for those who have kept right up with the subject will be comparatively easy—that is, you will have a fighting chance.

A QUOTATION FROM HOMER

Professor Albers (discussing business partnerships): Suppose one of the partners decides to take a vacation, and goes to Europe, while the other remains at home and works like a dog—but then, I think every dog has a snap.

The teacher holds out his watch:
"What is this?"
And the pupils all answer,—
"An Ingersoll."—A. M. S.

RING UP A LEAD NICKEL

Biz—"Say, old boy, are mushrooms dangerous?"

Whiz—"Oh, not necessarily; why?"

Biz—"Nothing, I just took in a sorority house party, that's all."

(Ed. Note—Don't give it up, it put us to sleep too.)—Siren.

Co-ed—Why didn't you find out which one he was when the professor called the roll?

Co-edotto—Because I couldn't distinguish which of the five he answered for he was.—California Pelican.

REMARKABLE ACHIEVEMENT

Professor Walker (discussing industrial filtration methods): The next kind is the Gravity Filter; now we'll run through some of these filters.

HERE'S ANOTHER TO PONDER OVER

Professor Lewis Jerome Johnson tells us that the rotary converter has revolutionized industry.

HUNTINGTON AVENUE

I came. I winked. I conquered.

THOSE NEW SEPARATED SEATS

Elizabeth—Did you have a good time out riding with Bill?

Helen—The idea of such a possibility! He has a new National.—Texas Coyote.

My best girl's name is Anna,
She kids me all the time.
She told me that she loved me,
And kissed me—it's a crime.

I went away to college;
I'm now a chemist wise,
And now it's awful easy
To tell when analyze.—Penn State Froth.

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THE KALENDAR

1. Admiral Dewey sweeps Manila Bay, 1898.
2. Up-to-date Spanish-American War news published by newspapers and the *Boston American*.
3. The tide in New York City rises six feet, or about two yards.
4. (Approx.) Eli Whitney invents non-alcoholic gin, 1793.
5. Elbridge Gerry Spaulding, "Father of the Greenback," died, 1897. (For the benefit of those who do not know what a Greenback looks like, we suggest a visit to the treasury of the Co-op.)
6. Ali marries Fatima, daughter of the prophet, 969 A. D. (Adv.)
7. Boston Elevated continues to provide greatest safety for its employees and poorest service for its patrons, of any road in the United States, 1915. (Disputed point.)
8. The first April shower begins on this day, 1915.
9. The cost of high living will not decrease to any great extent on this day.
10. Technology receives million dollar gift, ?915.
11. General Grant telegraphed: "I propose to fight it out on this line if it takes all summer," 1864. He did and it did, 1864.
12. Peace of Nicias, B. C. 421; alliance for fifty years between Athens and Sparta.
13. Spartan fleet destroyed by Athenians off Cyzicus, B. C. 410, eleven years after the beginning of the fifty-year alliance.
14. Peace between Athens and Sparta after the Peloponnesian War, B. C. 404.
15. Corinthian War: Athens and Allies versus Sparta, B. C. 395.
16. Athens accuses Sparta, and Sparta accuses Athens, of violating the rules of International Law, B. C. 410-395.
17. Water wasted in the chemical laboratories of the Institute on this day would reach, if placed in rubber tubing, from Beacon Hill, Boston, to Telegraph Hill, San Francisco.
18. Webster defines "Varnish" as "an artificial covering to give a fair appearance to any act or conduct."
19. Senior Class Day Committee, 1965, also congratulates itself on its proficiency as a varnisher.
20. Mohammed born, A. D. 570 or 571.
21. About this time, 1636, the second greatest educational institution in Massachusetts was founded in Cambridge.
22. Women dancers were first seen on French stage, 1681. (Origin of the ballet.)
23. Box office receipts of French theatres show remarkable advance, 1681.
24. The Institute Faculty numbers 121 members.
25. 121 members of the Institute Faculty tell their classes that they dislike nothing more than to give examinations, but that examinations are necessary, nevertheless.
26. Exams begin. 1800 Tech students wish they had studied harder during the term.
27. Demosthenes, after having been asked what his greatest desire was,

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replies, "Take me back to Tech," B. C. 342.

28. Russian fleet under Rozhestvensky (pronounced Czkocblmgmk) destroyed in Tshushima Strait, 1905.
29. (Sat.) Boston employs 250,371 men in the liquor business, of whom 250,189 are engaged in the consumption department.
30. Magellan undertakes trip around the world, 1520. Magellan's trip is eminently successful, except that Magellan is killed in the Philippines, 1522.
31. Decoration Day. Exercises of the Institute, which have already terminated for the summer, suspended for the celebration.

SMELLING SALTS, PLEASE

Biz—"I'm flat broke and can't find a job."

Ziz—"You remind me of Germany."

Biz—"Why is that?"

Ziz—"You're up against it."

Biz—"I don't follow you."

Ziz—"Oh, E-U-R-O-P-E against it, see?"—Siren.

St. Peter—"Gee whiz, since this war started I've been drawing so many that I've got a full house."

The Devil—"Aw that's nothing, I've got four kings down here."—Siren.

SCOUPING B. L. T.

Quizzer—"I understand they have quit using coal in Germany since the war."

Quizzee—"I wonder why that is?"

Quizzer—"Oh, too full of British Thermal Units, I guess." —Siren.

Old Lady—Pardon me, but is that the arc light?

Drummer—Just a minute, and I will light a match and see. —Punch Bowl.

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OH, THESE FEMINISTS!

"O say, who was here to see you last night?"

"Only Myrtle, father."

"Well, tell Myrtle that she left her pipe on the piano."

—Nebraska Awgwan.

A gay young Parisian de Laine
Long courted an heiress in vain,
When he said, "Now or niver!"
She answered, "Au river,"
So he promptly, of course, went in Seine.—Michigan Gargoyle.

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In kimona decollette (wow!)
Drives her twenty-mile Fordette
Out upon the Parkwayette.
Met her at the operette,
She entrapped me in her net;
I'm to be the husbandette
Of this lovely Henriette.—L. Y. G. in the Punch Bowl.

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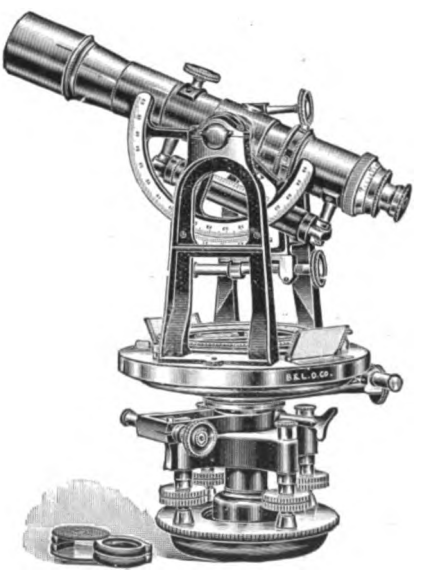

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"Oh, before I begin," he said, "I must find out your names."

"Marrius," said the bridegroom.

"Sure," said the J. P., "as soon as I find out your names."

"Marrius," said the groom.

"Yep," repeated the J. P., "but I must first know your full name."

"Will U. Marrius," said the groom.

"No," said the J. P., "I will be damned if I will."—Pennsylvania State Froth.

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I've plugged, and I've sweated and
hammered; my life has been one
of toil.
It ain't that I didn't like it, your subject
'as always 'ad charm,
But think o' my poor old mother—dad
breakin' his back on the farm;
I'm thirsty for eddycation, and that's
why they sent me here;
To get the money to do it pap sold four
cows and a steer.
Now ma she would weep like a fountain,
my pa would go off on a drunk,
To think that their dear only Willie, the
pride of their hearts, could flunk."

—L. L. E. in the Punch Bowl.

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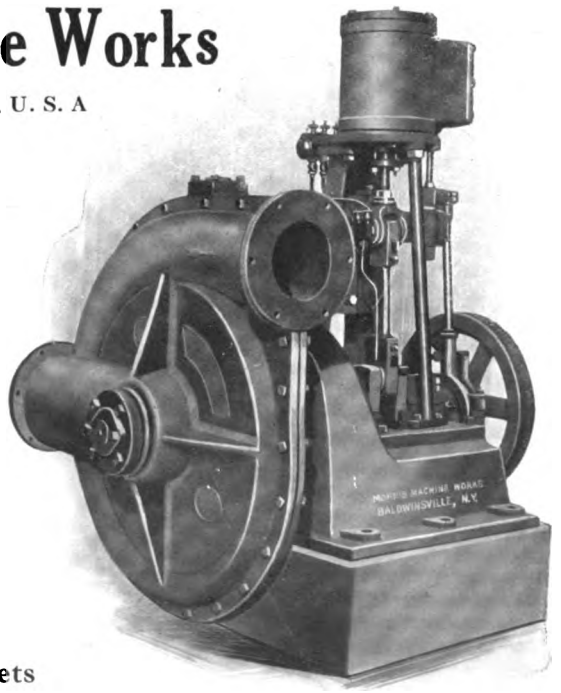

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Strange that whereas everything else in college has been steadily improved we are still punching the same old collar buttons through our shirts that our G. G. grandfathers fumbled. Shirts themselves have risen from the old rear-entranced through the front-and-trap door styles that went on like a skirt, and ruined many an eight-o'clock, to the coat shirt which is as easy to put on as a look of innocence in an exam. We have progressed from brass-eyeleted shoes to those with eyelets as invisible as tire punctures. Our garters, even though we be killed and eaten up clean, would still be found grimly holding up our socks; a few years ago garters were as rare on socks as they are today on gloves. Even cuff buttons have developed into cuff links, and suspenders from lengths of stair carpet into dainty bits of harness, and later into skate-strap belts. Although our overcoats look like a horse-blanket on a gate-post they have changed from the models of the old days—and that is more than can be said of the collar-button.

Oh, inventor, give thou us a better collar-button! We don't deserve it of course, but give thou us it anyhow!

—Siren.

A FORTUNE AWAITS THE MAN WHO INVENTS

A Gyroscope to balance our memory.

A Telescope to view any situation.

A Pulmotor to bring "dead-beats" to life.

A Barometer to determine the pressure of work.

An Aeroplane which will transport dull care away.

A Hydrometer to tell the density of deep thoughts.

A Speedometer to tell us how fast we are "going to the bad."

A Thermometer to test the heat of a burning heart when we are smitten.

A Periscope to find out "how the other half lives."

A Cyclometer to measure the wheel of our Fortune.

A Pedometer to measure the number of steps toward Matrimony (or Divorce).

An Aerometer to register the rate at which some people "blow."

An X-Ray to see through some of the questions we are asked (and some of the answers we receive).—D. T. B. in the Punch Bowl.

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She (coldly)—"Yes, I noticed during the dance." —Gargoyle.

Obe—Gosh, I'm absent-minded.

Joyful—What have you forgotten now?

Obe—Can't remember whether I used my Ford this morning or whether I walked *all* the way to the office.

—Purple Cow

Prof. (to co-ed reciting at Board in geometry)—Miss Smith, you have a very poor figure.

Co-ed (angrily)—Mind your own business. —Punch Bowl.

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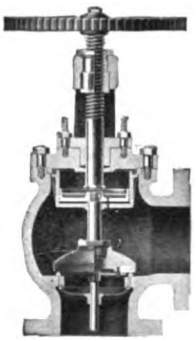

Fig. 293
Sectional View of Automatic Stop and Check Valve, Angle Pattern

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The TECHNOLOGY MONTHLY

And

HARVARD ENGINEERING JOURNAL

June 1915 Vol. II, No. 3

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The Technology Monthly
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A magazine devoted to the interests of the Massachusetts Institute of Technology—The Official Organ of the Association of Harvard Engineers

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Copyright, 1915, by The Technology Monthly

Entered as second-class matter at the post office, at Boston, Mass. Published monthly during the college year by the students of the Massachusetts Institute of Technology. Publication office, Technology Union Building, 42 Trinity Place, Boston. Harvard Editorial Office, 218 Pierce Building, Cambridge, Mass.

Mail Address: Technology Monthly, M. I. T., Boston, Mass.

Phone Back Bay 2180, Private Exchange

Subscription rate, $1.50 per year; 25c. per copy. Advertising rates upon application.

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THE TECHNOLOGY MONTHLY
AND HARVARD ENGINEERING JOURNAL

VOL. II BOSTON, MASS., JUNE, 1915 NO. 3

INTERIOR LAYOUT OF THE NEW INSTITUTE

THE FIRST PUBLISHED PLANS OF THE VARIOUS DEPARTMENTS

EVER since the idea of a new Massachusetts Institute of Technology was projected in the minds of those who saw the rapidly increasing needs for the change, views have appeared with more or less regularity, showing, at first, the architects' conceptions of the new Institute, and, more recently, photographs illustrating the progress of the work. Practically all portrayals have been confined, however, to the outside appearance of the buildings.

In presenting to our readers, consequently, the following six pages of plans the editors have concluded that, with the exterior appearance of the group fairly well known among Institute men, the points of greatest immediate interest to all concerned were the location of the various departments, the special features in regard to equipment, etc.

No attempt has been made to make the set of plans complete. Needless to say, such an attempt, involving a reproduction of some thirty-four sets of main plans of the buildings, was infeasible. The editors have taken pains, therefore, to select from the number a set of views each of which, though representing a specific department, presents, nevertheless, a typical interior layout, a characteristic plot of the intended construction. They believe that within the scope of this presentation the plans shown will convey to the reader more information in general than any other selection which might have been presented.

The plans are absolutely authoritative and up-to-date in all respects, the reproductions—reduced about 35 times in area—having been made from the original working tracings issued to the Monthly directly by the contractors, the Stone and Webster Engineering Corporation. So far as is known, the views have never before been published, and are the only comprehensive set to be found outside the offices of those directly connected with the work.

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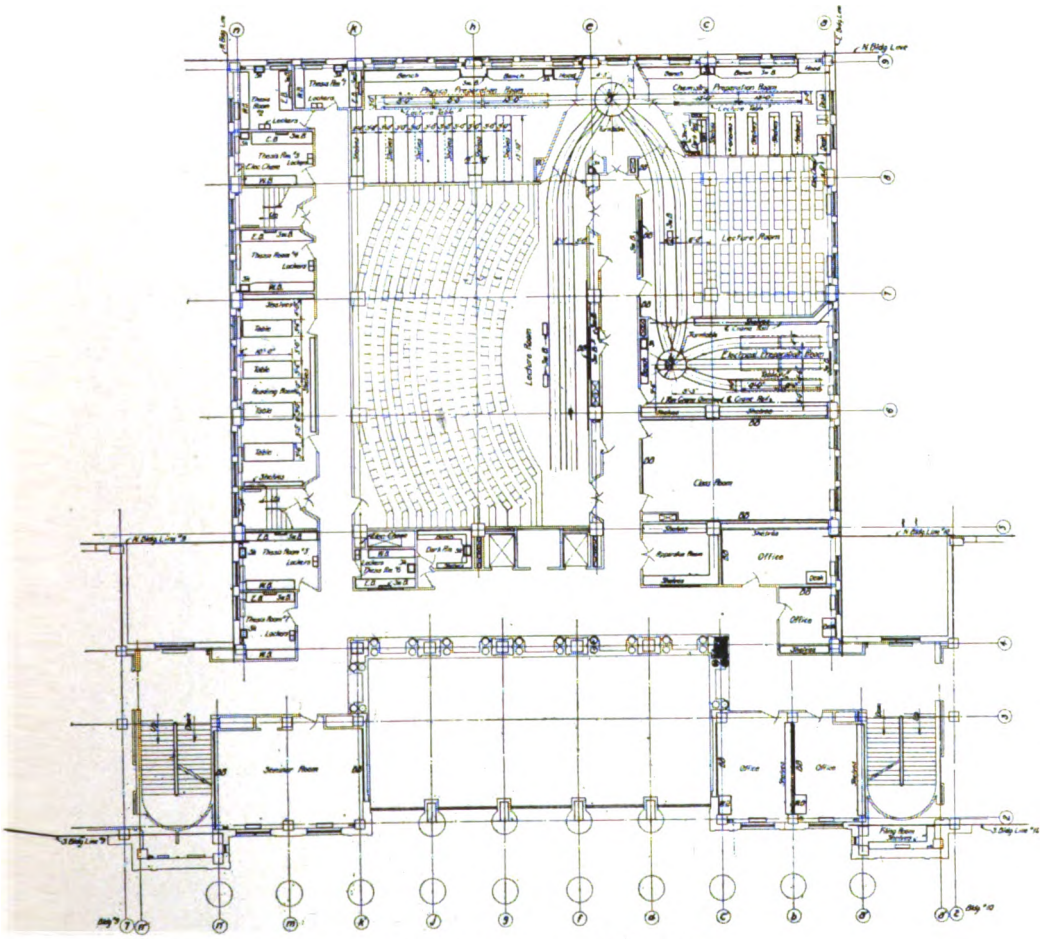

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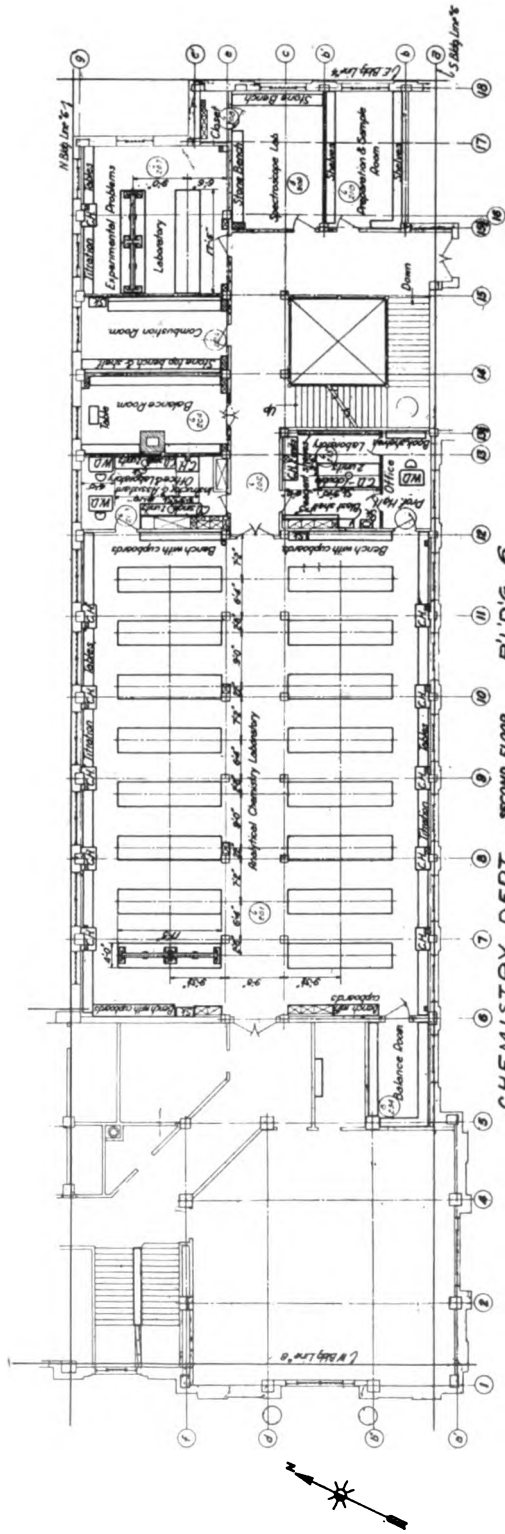

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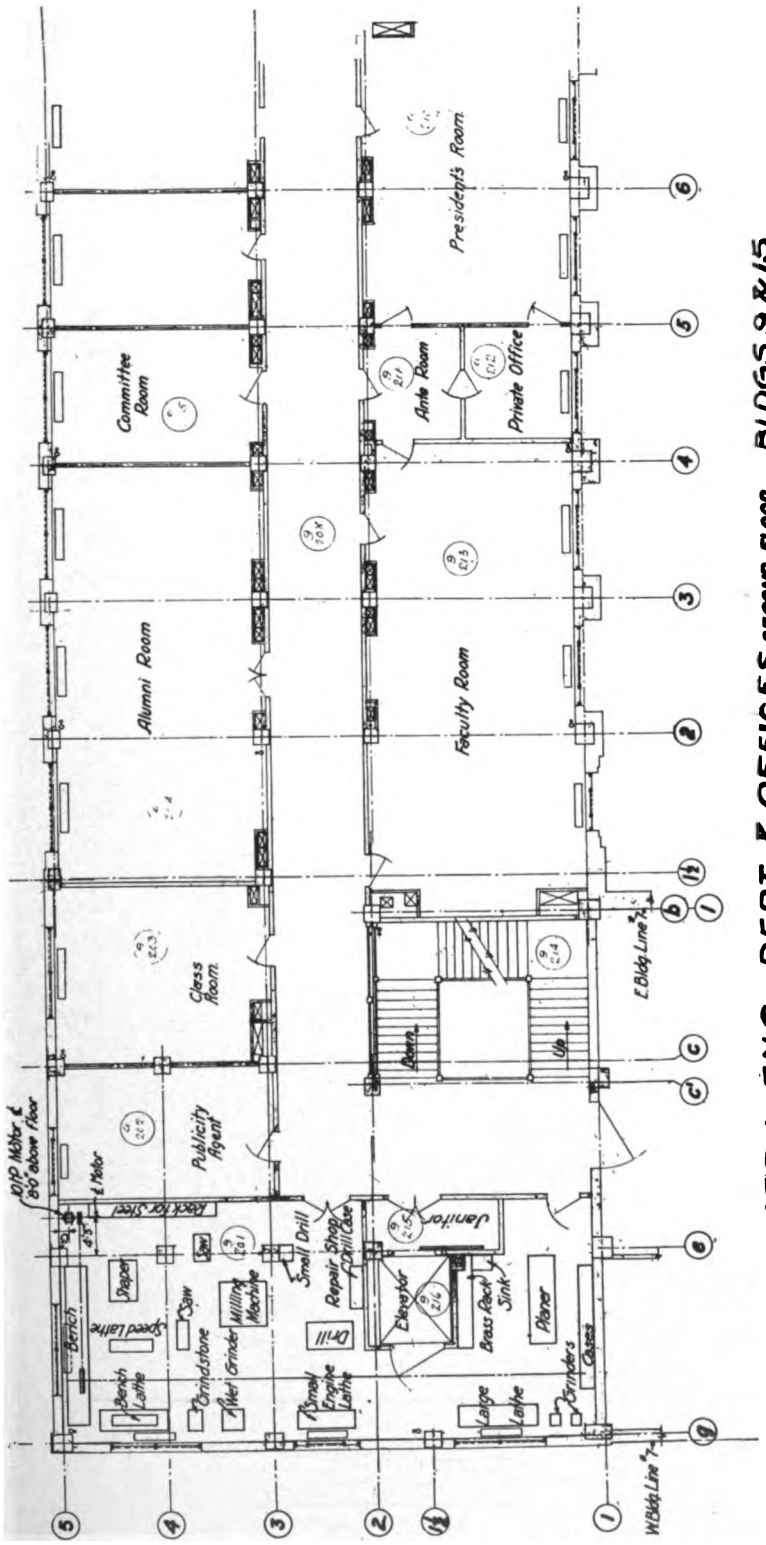

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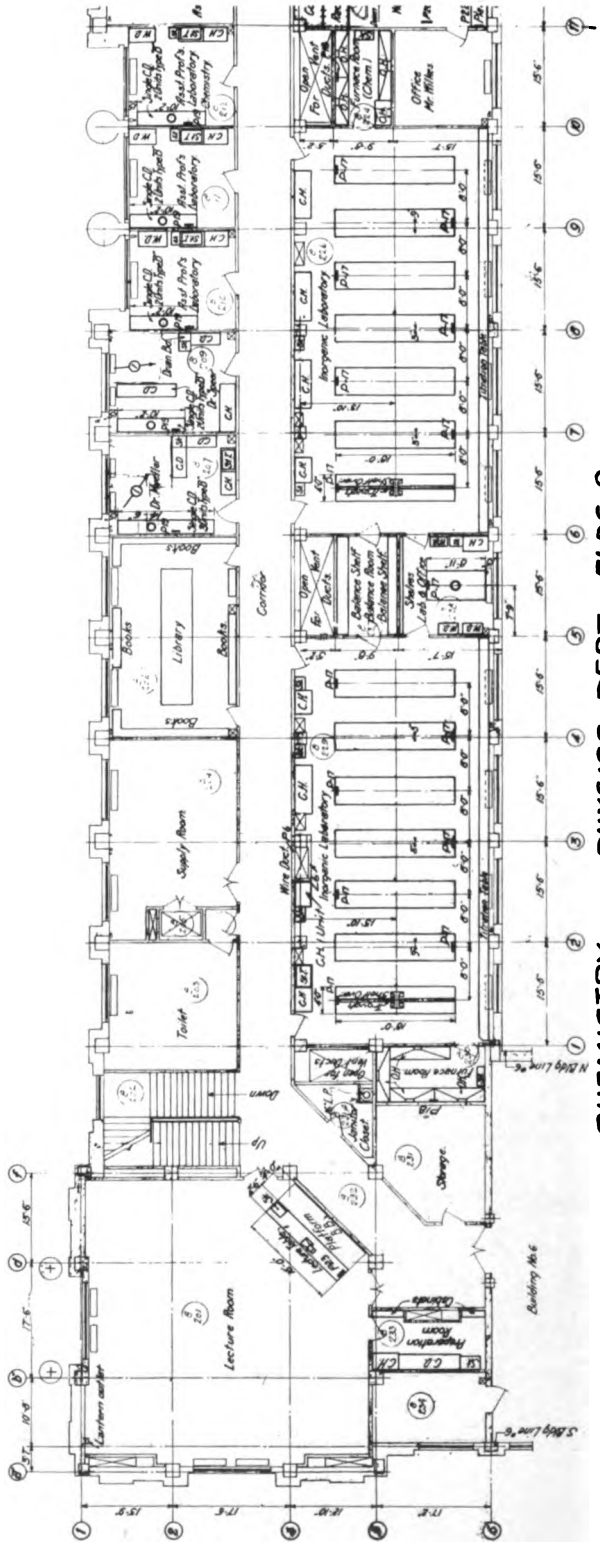

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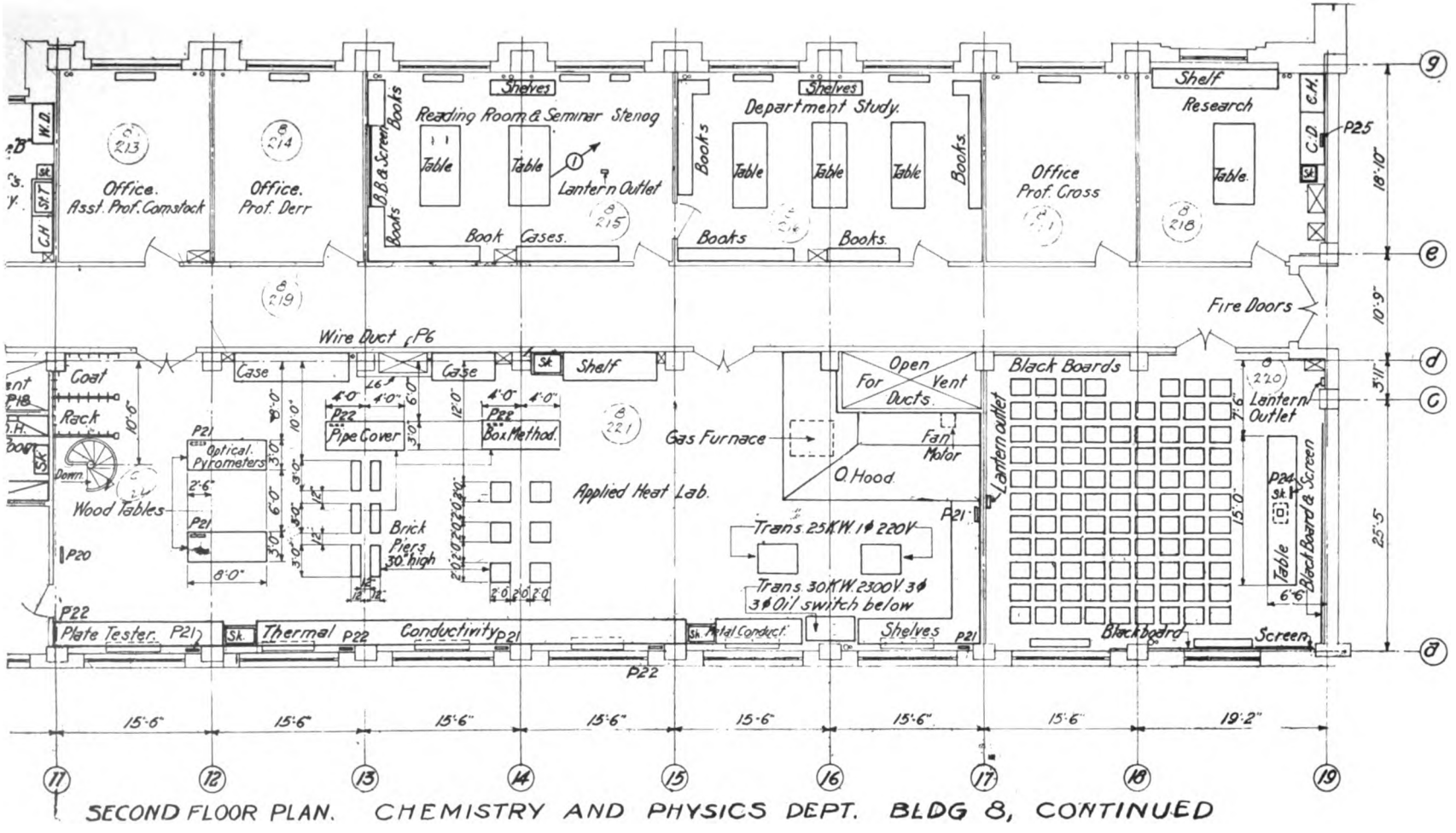

SECOND FLOOR PLAN. CHEMISTRY AND PHYSICS DEPT. BLDG 8, CONTINUED

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Candidates who obtain assignments to be covered during the summer months will possess a slight advantage over the members of the incoming class. Students below the Fourth year are eligible.

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MASTER FORMULAE AND VARIOUS CALCULATIONS

By WALTER C. DURFEE

Editor's Note. In presenting this article, which has for its purpose the useful classification of formulae and calculations for the Practicing Engineer as well as for the student in the Engineering School who finds difficulty preparing for his final examinations, the editors of the Technology Monthly and Harvard Engineering Journal take pleasure in calling attention to the fact that Mr. Durfee was an Editor-in-Chief of the Harvard Engineering Journal before its merger with the Technology Monthly. In connection with the Journal as well as with the firm of Winthrop C. Durfee, Consulting Engineers, Mr. Durfee has had opportunity to select from the mass of engineering formulae and data the useful ones,—those which will aid the student, and the engineering graduate as well.

NEARLY every man carries with him at all times two maps; exquisite, ever accurate, ever changing: two maps of his immediate surroundings. The great value of maps first impressed me some sixteen years ago, while reading the story of an ancient war. I imagined the hero of that story in the midst of disaster, surrounded by strange rivers and mountains. I thought, "How happy he must have been if he had just one good map—a map of the way out."

A little later I lay in the grass, on a holiday, and watched the little insects crawling up the blades; and most often crawling down again. The thought occurred to me, "Those insects remind me of myself, and those blades of grass remind me of the many things that my instructors teach in school. I wish that I had a map to go by—a map of the field of thought."

Here in this article I shall present to my readers a map of a field of thought. It is a map of a part of the realm of Engineering Calculations. I shall hope to show that this field is more a garden than a labyrinth.

THE KEY MAP

How shall we lay out a map of Engineering Calculations? What shall be the east and the west of the map? What shall be the north and the south?

Fortunately for this question, it happens that natural scientists have long examined their aspect of the world, using their most wonderful kaleidoscopes.

They have chosen three things as a suitable basis for Engineering Calculations. These three things are closely interlocked, interlocked as it were by the mechanism of the whole world. The three are, Mass, Time and Distance. In a figurative way time and distance are the father and the mother in this little family. In fact astronomers, driven by necessity, often treat mass as if it were a sort of definite relation between time and distance.

In figure 1, page 15, is a key map of Engineering Calculations, in which the master formulae of Engineering are laid out in accord with this highly convenient astronomic makeshift. On this map "distance" is east and its opposite is west. "Time" is north and its opposite is south. The opposite of time is frequency.

Degrees of longitude and latitude on this map have a most curious and useful value. You will see that "length," "area," and "volume" are placed on

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the map in the first, second, and third degree of distance, because these things are calculated respectively in terms of distance to the first, second, and third powers.

Around the position of "mass" on the kep map you will find located "momentum," "force," "pressure," "energy," and "power," all in strict accord with the accepted master formulae of Engineering. For instance, you will see on the map that "force" is separate from "mass" by just the longitude and latitude of "acceleration" (Force equals mass times acceleration.)*

"Mass" itself has no orthodox position. For convenience I have put it on the map in the longitude of "volume" and in the latitude of "acceleration."

VALUE OF THE KEY MAP

This map as it stands contains practically all of the master formulae of mechanics: those fundamental formulae from which more usable and complex formulae are built.

As examples of such formulae I shall choose four, which relate to hydraulic head, and one which relates to a nameless quantity which is reckoned in the same dimensions as hydraulic head.

(1) (Velocity)^2 of a fluid is proportional to Hydraulic Head.
(2) Acceleration [gravity] × Distance [height] is proportional to Hydraulic Head.
(3) Acceleration [of fluid] × Distance [length] is proportional to Hydraulic Head.
(4) Pressure ÷ Density is proportional to Hydraulic Head.
(5) Elasticity ÷ Density is proportional to (Velocity)^2 of Sound.

To trace such formulae on the map, you start with the first quantity (say velocity) and add to it the longitude and latitude of the second quantity (say velocity again). That brings you to the longitude and latitude of the product (velocity squared or hydraulic head).

Try adding up the positions of acceleration, L^1T^{-2}, and of distance, L. You come to L^2T^{-2}, the position of velocity squared or hydraulic head.

If you want a quotient instead of a product you subtract instead of add. For example, find "pressure" on the map and subtract from that position the position of density. You find that the quotient of pressure over density is hydraulic head.

PRACTICAL FORMULAE

Such fundamental formulae as I have mentioned, and others like them, are mere statements of the general relations between things. Such formulae canot be used like a hoe. To obtain at first hand any practical and reliable working formulae you must begin with the fundamental formulae and fashion them to suit your needs. That is the use of mathematics.

DETAIL MAP

A most interesting story could be told, going over the key map step by step. Under the head of time or age I should speak of the formation of producer gas, the setting of cement, the behavior of materials in the testing machine. These processes respectively require seconds or fractions of seconds, months or years, minutes or hours. Under the heading of curvature [usually equals reciprocal of radius] I should speak of the curious nomenclatures adopted by railroad people, opticians, and others.

* Acceleration is represented by a move on the map as in a game of chess. If you move from "number" on the map one degree to the right and two degrees down you come to acceleration. Take that same move from "mass"; you land on "force."

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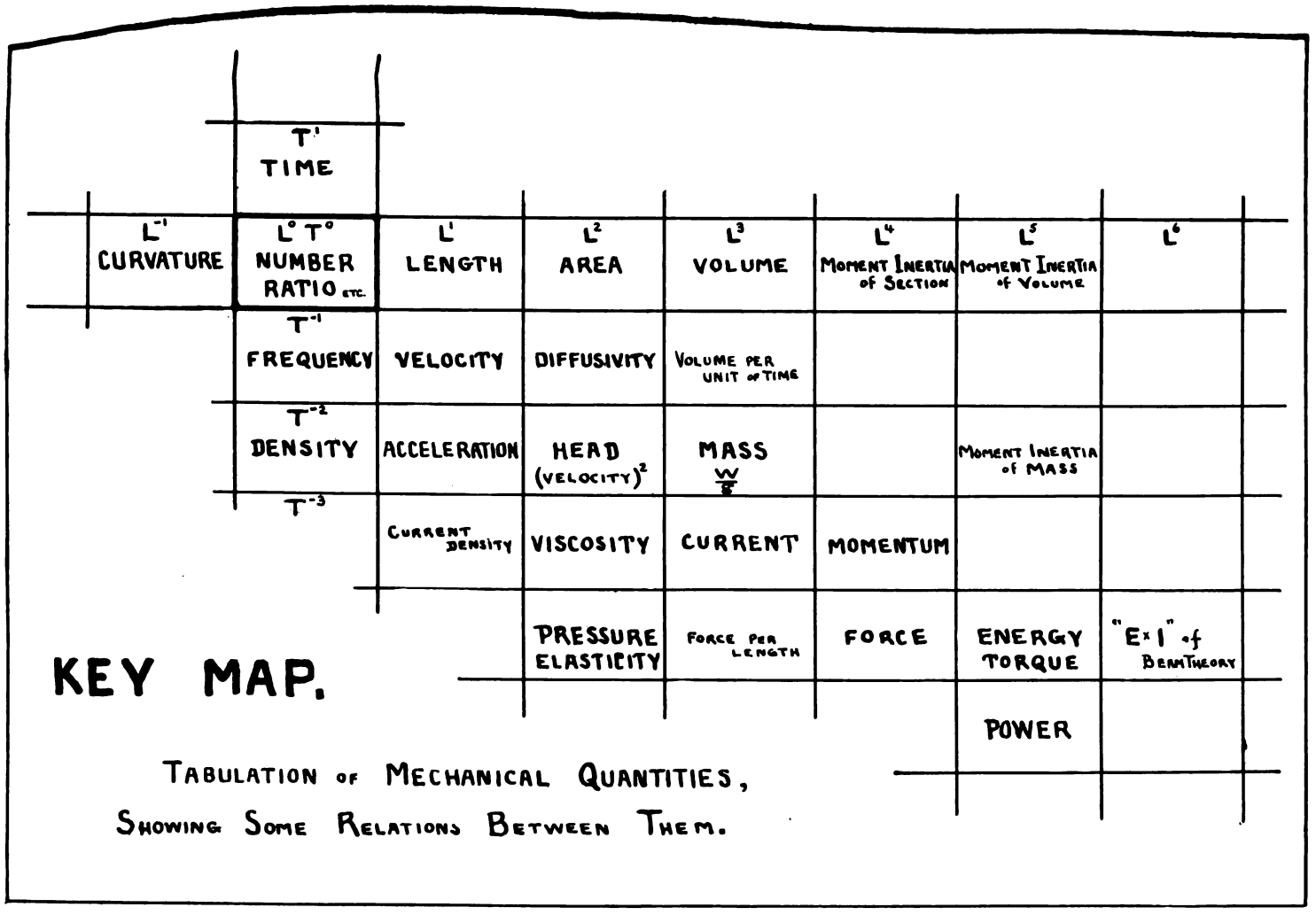

TABULATION OF MECHANICAL QUANTITIES,
SHOWING SOME RELATIONS BETWEEN THEM.

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However, I shall pass over these points, presenting as a solitary example of detail maps of engineering the one which is shown in figure 2, page 17. It is a map of various magnitudes and measures of length or distance.

HELPFUL INFORMATION

Throughout the remainder of this article I shall try to say something helpful about the use and the study of engineering formulae.

While at college I took pains to ask a few of the professors how they had managed to become so well informed. In reply one very kindly showed me a great filing cabinet in his house. The answer of another was to this effect: "Digest your information; if you do not digest it, it will never be of any use to you."

For this reason the following is presented as a sort of memorandum of the construction and make-up of Engineering Formulae and of the use of formulae and I hope that this will prove helpful in the study and unraveling of such applications.

THE CONSTRUCTION AND MAKE-UP OF FORMULAE

Coefficients. In the calculation of the displacement of a ship from the product of its length, breadth, and draught, a coefficient of from 0.55 to 0.78 may be used *to show how much of that product to take for an answer.* Every thoroughbred formula has some numerical coefficient of this sort. The number of 0.78 is used in calculating the area of a circle from its diameter squared.

Factors. In the calculation of the performance of a steam boiler a factor of from 1.00 to 1.25 is used to multiply the actual evaporation up to a standard equivalent of "water evaporated into dry steam from and at 212° Fahrenheit." Most all practical calculations contain factors as multipliers,—thus the factor of safety multiplies up the safe load to the load which represents the calculated breaking load.

Efficiencies. Usually efficiencies are numbers obtained from experience. The net result that you may expect from putting heat into a boiler or electric power into a system of power transmission is represented by some fraction of the whole, say 0.75. Such numbers are found very frequently in engineering calculations.

Units of Measure. Great attention must be paid to units of weights and measure. A safeguard is to use a system of cancellation, thus:

$$5 \text{ (kilometers)} \times 3280.8 \frac{\text{(feet)}}{\text{(per kilometer)}} \times \frac{12 \text{ inches}}{\text{(per foot)}} = 196{,}848 \text{ inches.}$$

Engineering formulae are crowded with such terms; for example, 777.5 ft. lbs., *per* British thermal unit; 3600 seconds *per* hour, etc.

Moduli. Modulus means measure; the measure of some quality. The measure or modulus of the elasticity of steel is about 30,000,000 pounds force per square inch per unit elongation. Thus, for an elongation of .0001, or one part in 10,000, the stress amounts to 3,000 pounds per square inch. For copper the modulus of elasticity is about half as much.

CONFUSIONS, MIXTURES, CONTRACTIONS

Moduli, units of measure, factors, coefficients, efficiencies; all are used for one purpose: to modify a general formula toward a special use.

For good reasons it is a common custom to confuse each of these terms with each other, to mix their names, to lump them together into a single

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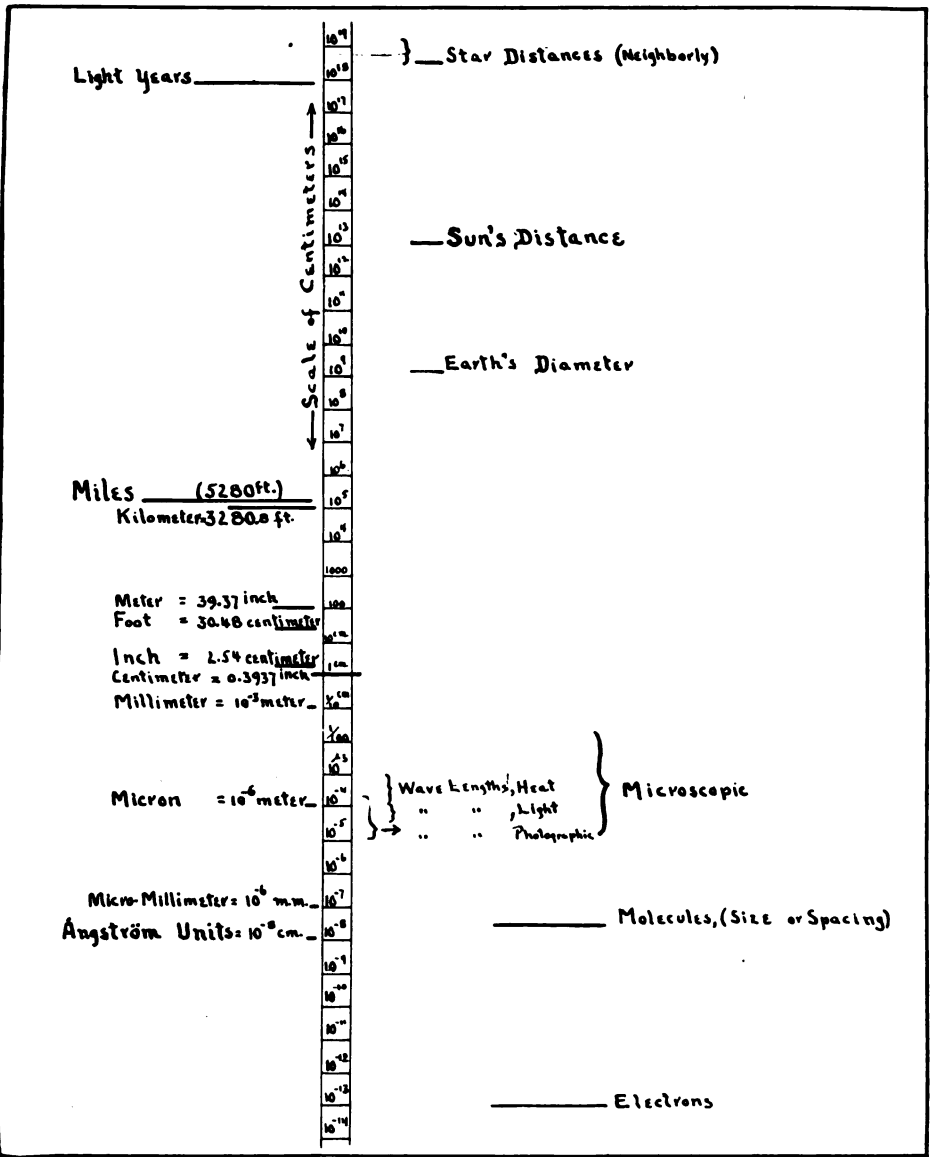

VARIOUS MEASURES OF LENGTH OR DISTANCE.

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number,—even to omit the mention of essential parts of a formula.

For example, the Indicated Horsepower of a steamship is reckoned at about 1-240 times the two-thirds power of the displacement in tons times the cube of the speed in knots.

Taking this formula solely on its face value, it is a fair guess to say that the number 1-240 is a compound of several coefficients [of the form of the ships and the flow of the water], several efficiencies [of engines, propellers, etc.], and several units of measure [for converting tons and velocities into horsepower].

Moreover the "2-3 power of a ton" probably should be a 2-3 power of a volume times the density of a fluid. Such questions, however, are not worth answering unless you wish to use the formula for some unusual purpose like the design of an airship. The original formula in its native simplicity is the proper one for ordinary use.

COMPLEX FORMULAE

Simple formulae are worked up into complex formulae by methods of calculus, geometry, and other mathematical processes. Wonderful formulae for the strength of beams are obtained in this way.

Several formulae are often welded together into a single compound formula. There is such a one which relates to power transmission by means of leather belts or by manila ropes. A manila rope (1-inch diameter) is credited with a reasonable usefulness amounting to about 12 Horsepower if run on a rope drive at speeds from 60-ft.-sec. to 100-ft.-sec. At either higher or lower speeds it becomes much less useful. The gist of the calculation is this:

Effective pull in lbs. x *velocity* in ft.-sec. ÷ 550 (ft.-lb. per sec.) per H.P. equals Horsepower. A calculation for centrifugal force at high speed cuts deeply into the calculation of effective pull. At low speeds the lack of velocity cuts deeply into the formula, first mentioned, for Horsepower.

EMPIRICAL AND IRRATIONAL FORMULAE

Some engineering formulae are like shadows on rough ground. They are perfectly true to the facts; but at the same time so much distorted that no one can see a resemblance between the formula and the quantity it represents. Very hard ground has to be broken before these formulae are straightened out.

Such formulae are for limited use only. To extend or expand them even a little is not a conservative or dependable operation. For example, there is an apparently empiric tabulation in the handbooks of the sliding friction of steel tires on steel rails. Extend this beyond its proper range (10-50 miles per hour) and you come to the inference that a train of cars could run very easily on skids instead of wheels at a speed of 200 miles per hour,—could even coast on a 1-5 per cent grade if not hindered by the wind or something else.

CONCLUSION

This brief review of the make-up of engineering formulae is now at an end. Together with the classification of fundamental quantities given in the key map, I hope that this will serve as a helpful memorandum for those few of my readers who care for studies of this kind.

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IN DEFENSE OF SECTARIAN SOCIETIES AT TECHNOLOGY

Editorial Note. As is customary in cases of this nature involving a two-sided discussion, the pages of the Monthly merely constitute a Forum for the exchange of opinions. The sentiments expressed below do not represent the editorial policy of the magazine, but may be taken as an official reply from the Catholic Club, of which the writer is a member.

IN the May issue of the Monthly there appeared a communication criticizing sectarian societies at the Institute, which communication should not go unanswered, for I believe that it reflects only a very small part of the sentiment towards those societies among the student body. The writer evidently failed to inform himself fully upon this question or he would not have made some of the statements he did.

Each argument advanced by the communicant as to why "students should decline to join sectarian societies" and why he considers that "sectarian societies are a menace to the brotherly spirit of fellowship which we should try to develop at M. I. T.," is easily answered. Also I shall endeavor to clear up any further misunderstanding which may exist in the minds of others through failure to have sufficient information concerning these societies. The "two religious societies whose membership and motives are sectarian" which now exist are the "Brotherhood of St. Andrew" and the "M. I. T. Catholic Club"—at least I believe those are the ones the writer was referring to. I may state now in the beginning that I am a member of the society which is justly proud of having "an enrollment of approximately ten per cent of the student body"—the M. I. T. Catholic club.

The writer of the attack on these societies says that "sectarian societies breed race feeling." He evidently fails to make a distinction between race and creed; what he is talking about is creed prejudice and not race prejudice, as he stated. Creed prejudice does not cause race prejudice because different creeds exist in the same race and different races have the same creeds, as the outcome of the excellent missionary work that is now being carried on among all races. Sectarian societies are not a form of segregation, as they by no means prevent a free interrelationship between members of different religions.

"A certain religion is nothing more than the ticket of admission to the societies," says the writer. In this particular case this statement is quite true and is paralleled in the case of our own professional societies. In order to join the Chemical Society (of which the writer of the communication to which I refer, is a member) a man must be in a course having chemistry for a major subject,—that is "his ticket of admission." All societies have requirements for admission which admit certain people and exclude all others.

The beginnings of a man's religion are naturally those taught by his parents as part of their duty toward their child, the same as a child brought up in a certain country speaks its language. However, when that child reaches manhood and a thinking age he is at liberty to choose his own religious faith. Every thinking man is bound to give a great amount of thought to something so high as religion. If his present religion satisfies him he will continue in that belief;

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if not, he seeks another and if that other appeals more to his faith he will change. No thinking man will follow the "religious views dictated to him" if he does not believe in them. The large numbers of converts to all religions prove this and I know personally of cases where members of the clergy have even changed their religion, a not uncommon occurrence.

Sectarian societies at Technology do not "spell social ostracism for our talented foreign students"—a deplorable result feared by the writer of the communication. The M. I. T. Catholic Club has among its members a good percentage of foreign students and I do not doubt that this is also the case with the other sectarian societies at the Institute. I feel sure that all the foreigners now at the Institute possess religious views of some sort, and are only too glad to find some common bond to unite them to other men.

Having answered all the arguments against the presence of sectarian societies at Technology as advanced by the writer of the communication, I will give some information concerning one of them for the benefit of those who hold misguided views on the subject.

The object of the M. I. T. Catholic Club is the development of social life among Catholics at the Institute and to provide a means to foster their religion. Speakers of prominence are secured for the informal meetings to talk on subjects of current interest which may or may not be of a religious character; also the speaker may or may not even be a Catholic. The meetings of the Catholic Club, including its annual dance, are at all times open to any student at the Institute, irrespective of race or creed, who desires to attend and in the name of the the President of the Club I extend a cordial invitation to the writer of the communication in the last issue to be present at the next meeting of the Club.

In all my four years at Tech nothing has come to my ears in the way of adverse comment on the existence of sectarian societies nor has any prejudice or race feeling been in evidence as a result of their existence. On the contrary their existence has been spoken of as extremely beneficial by many including no less a person than Dean Burton, the overseer of the students' welfare. In fact he has been a speaker at meetings of the Catholic Club, although not a Catholic, and he has spoken very highly of the good work which is being done by it.

The Catholic Club can no more "let down the bars of sectarian differences and throw open its membership to all creeds" as demanded by the communicant, than the Chemical Society can admit architects to its membership, but it does and always will admit men of all races.

I have endeavored to correct any false impressions which may exist and still believe that the former letter was written chiefly through ignorance of the existing purpose and situation of sectarian societies at the Institute. I trust that I have exhibited no animosity towards my predecessor, as none was intended. I felt that this communication should not go unanswered in the organ in which it was published, because of the views presented therein, and I have endeavored to state the case from the point of view of a member of one of the societies referred to and trust that I am supported in my opinions by the other similar societies.

Francis C. Foote, '15

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CARBORUNDUM

WHAT IT IS AND HOW IT IS MADE

CARBORUNDUM is the trade name of an abrasive which is made by heating a mixture of sand, coke, sawdust, and salt in an electric furnace. It is a definite chemical compound formed from the silicon of the sand and the carbon of which the coke is composed. It may be considered either a silicide of carbon with the chemical symbol CSi, or a carbide of silicon with the chemical symbol SiC. The sawdust and salt are added to the furnace charge or mix for reasons which will be given later.

Carborundum was not known in the crystalline form until the electric furnace was devised. However, a compound having the same chemical composition had been prepared and described by several chemists. This substance, which was green, soft, and noncrystalline, had no commercial value whatever and was simply a chemical curiosity. To form crystals of carborundum a heat of tremendous intensity was required, and it was the electric furnace which made possible the production of this high temperature. It was simply a question of using electricity as a fuel and thereby producing a temperature which could not be attained by any known heating agent.

In 1891 crystalline carborundum was first prepared in a small electric furnace at Monongahela City, Pennsylvania. This fact is interesting historically, because carborundum was one of the first substances produced in the electric furnace. The furnace used by Mr. E. G. Acheson in this experiment was a small iron bowl which was connected to one terminal of the dynamo. The bowl was filled with a mixture of clay and carbon. Into this mass was plunged a carbon rod, which, in turn, was connected to one terminal of the dynamo. After the current had been passed through the mixture for a certain time the connection was broken and the carbon rod was removed from the mass. Adhering to the end were small crystals of some substance which sparkled like a diamond. Experiment showed that these sparkling bits were very hard and cut glass very easily. People who like myths and fairy tales say that the investigator hoped to form diamonds by this method. If this was his aim, he failed, but not by a wide margin, for the new substance was almost as hard as the diamond although not so suitable as a gem. The story goes that the new substance was called carborundum because the experimenter thought it was a compound of carbon and aluminum oxide which is a constituent of clay. When crystalline aluminum oxide is found in nature it is called corundum. So carborundum is a new word created from the two words, carbon and corundum.

The iron bowl was soon discarded for a furnace which was constructed of bricks and which was ten inches long, four inches wide, and four inches deep. In furnaces of this size, the Carborundum Company produced fifty pounds of carborundum in 1891, the

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first year of its existence. A large part of this output was sold for gem polishing and valve grinding. The present-day furnaces are 30 feet long, 12 feet wide, and 10 feet deep, and represent a thirty-nine thousand fold increase in capacity over the furnaces used in 1891. There are twenty-one furnaces in the furnace department, which are in continuous operation for twenty-four hours a day and seven days a week. The production of carborundum this year will be approximately 15,000,000 pounds.

The furnaces are built with concrete end walls which contain the electrode terminals and with side walls composed of several sectional units of fire-brick set in iron frames. This construction facilitates the loading and discharging of the furnaces.

In charging the furnace, the mixture of sand, powdered coke, sawdust, and salt is fed into the furnace from an overhead conveyor until the furnace is half filled. Then a core of carbon is built through the furnace from end to end, the upper half of the furnace sides are set in place and the furnace filled heaping full of charge. The furnaces are known as resistance furnaces and the heating effect is due to the transformation of electrical energy into heat when the electricity encounters resistance as it flows through the conducting medium. This heating effect may be illustrated in the electric light bulb. Here the electric current encounters the resistance of the filament and is transformed thermally in sufficient quantities to raise the temperature of the filament to a white heat. So the carbon core in the carborundum furnace is like the filament in the electric light bulb and is heated to a terrific temperature by the tremendous current which flows through the furnace. The current surging through the core is forty thousand times as great as the current which flows through the sixteen candle-power carbon incandescent lamp. This mighty flow of electricity is great enough to heat the carbon core so dazzingly white-hot that no eye could withstand its brilliancy. At this temperature, iron would boil like water on a hot stove and fire-clay would melt like butter. The furnace ends are cooled by a water-circulating system to protect them from the intense heat. Under the influence of this amazing temperature, the sand and carbon combine while carbon monoxide gas is given off and works its way to the outside through channels made by the burned sawdust which is added to the charge to make it porous and so allow the gas to escape freely. If sawdust were not added, the gas would collect in the interior of the furnace until a sufficient pressure was generated to enable it to force its way to the surface. This would mean vast upheavals of the furnace charge. However, with the sawdust, the reaction proceeds quietly and peacefully and the gas reaches the surface, where it burns with the blue flame like that noticed when a fresh supply of coal is put on the fire. During the run, the furnace is wreathed in short, darting blue flames, sometimes tinged with yellow color from the burning salt, and looks like the fiery furnace it really is. The salt is added because it forms volatile compounds with impurities which are found in small amounts in the ingredients of the furnace mix. This improves the quality of the carborundum. The furnace is designed throughout to withstand high temperatures and to allow free escape of the gases given off during

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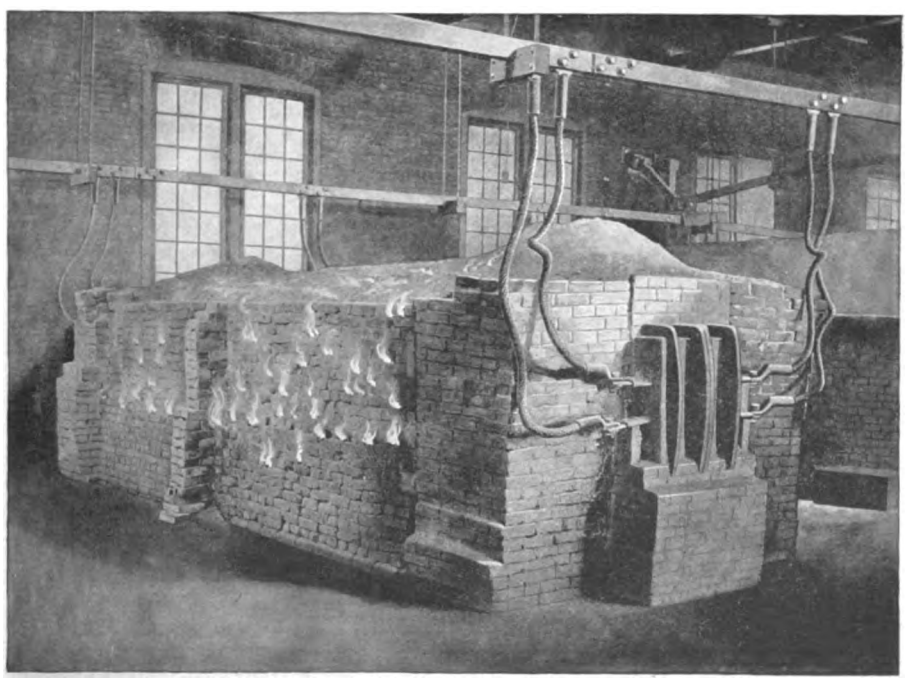
the chemical reaction in which carborundum is formed.

In the interior of the furnace the silicon, which is formed by the reduction of the sand (silica) and the carbon, seeks refuge from the relentless heat by forming a substance which can withstand the ferocity of the temperature. Such a substance is carborundum, which is a refractory substance as well as an abrasive. At the points where the heat is most intense two interesting changes take place. First, carbon as coke is transformed into graphite; second, the carborundum is decomposed into its constituents, silicon and carbon. The silicon vaporizes and leaves the "graphite skeleton of the carborundum crystals," a mute testimonial of the terrific temperature. Because these two changes do take place, the length of the furnace run must be regulated. Experiments have shown the best results are obtained by a run of thirty-six hours. During this time enough electrical energy is consumed to operate an arc light continuously day and night for twelve years, or to operate one sixteen-candle-power carbon incandescent lamp for 220 years.

At the conclusion of the run, the electric circuit is broken and the furnace is allowed to cool. Then it is seen that the charge has shrunk appreciably, due to the sawdust burning out and to the loss of volume which the charge undergoes during the formation of the carborundum. When the furnace has cooled sufficiently, the sidewalls are removed and the dismantling begun. The top crust is scraped off and the layer of "fire sand" exposed. This "fire sand" is a compound composed of silicon, carbon, and oxygen, and represents an intermediate step in the formation of carborundum. It is, of course,



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formed at a lower temperature than carborundum. Beneath the fire sand is the carborundum, forming a huge ring around the core. In contact with the core a thin, irregular ring of graphite is found. A cross-section of the furnace dismantled would show the fire sand, carborundum, and graphite, arranged in concentric rings around the core. Each one of these rings represents a zone of temperature which decreases in intensity from the core outward. In each run the average yield of carborundum is about nine tons.

The huge lumps of carborundum crystals are loaded into iron carts and trundled across the yard from the furnaces to the crushing department. A cart-load of these crystals presents a beautiful sight. The coloring is magnificent and outrivals the splendor of the rainbow. Every tint is represented and adequate reproduction of the blending and iridescence defies the printer's ink and the artist's brush. It is a severe jolt to the artistic sense to see these wonderful colors disappear beneath the roll crushers. These things of beauty are not joys for long when the two-ton rolls pass over them a few times. But the crushing department is only the next step on the way toward transforming the beautiful, glistening crystals of carborundum into useful grinding wheels and sharpening stones.

Nature has provided man with materials for use as abrasives. These include the diamond, corundum, emery, sandstone, and several varieties of silicate rock, such as garnet and the oil-stones. But of all the abrasives, both natural and artificial, carborundum is the most interesting for a number of reasons. First, it is unique as a chemical compound in that it is composed of silicon, which is the backbone of the inorganic or non-living world, and of carbon, which is the backbone of the organic or living world as well as a very important constituent of the inorganic. Second, it is not found in nature except in very small amounts in meteorites which have fallen to earth. One authentic case of its occurrence in a "fallen star" in on record. A large meteor was discovered near Cañon Diablo, Arizona, in which carborundum was found embedded in iron together with several small diamonds. The fact that the carborundum was found in a meteorite, which is just a flying spark from the seething furnace of the universe, is another indication that the temperature at which carborundum is formed is very high. This suggests the third point by which carborundum is distinguished—the high temperature at which it is formed. It is very difficult to measure the exact temperature at which silicon and carbon unite to form carborundum, although several attempts have been made recently. These measurements show that the formation temperature is about 3,300 degrees Fahrenheit, but it is more than likely that the actual temperature on the interior of the furnace is at least twice that indicated by the methods used. One fact, however, is certain—the temperature is one of the highest found in any industrial process. This tremendous temperature brings out another point in which the carborundum furnace is unparalleled. Most substances which require heat for their formation are heated in containers which can withstand the temperature. There is no substance which could be used in constructing these containers for the carborundum furnace. Hence a big step ahead was made when the unchanged "charge" or "mix" held in place by fire-brick walls was utilized for this pur-

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pose. The internal heating made possible by the design of the furnace gave the intensely localized temperature which carborundum requires for its formation. The use of the unchanged charge for the container is the fourth point which distinguishes the carborundum furnace from all other industrial furnaces.

Such is the process by which carborundum is created. The crystals are then crushed, purified with acid, washed, dried, graded into twenty-one grits by sieving, mixed with bonding material and formed into wheels or sharpening stones, fired or baked in kilns, finished, and tested. All of these processes require time. Six weeks after the carborundum crystals leave the furnace they come to the shipping room incorporated into a grinding wheel and ready to go forth, "the right wheel in the right place."

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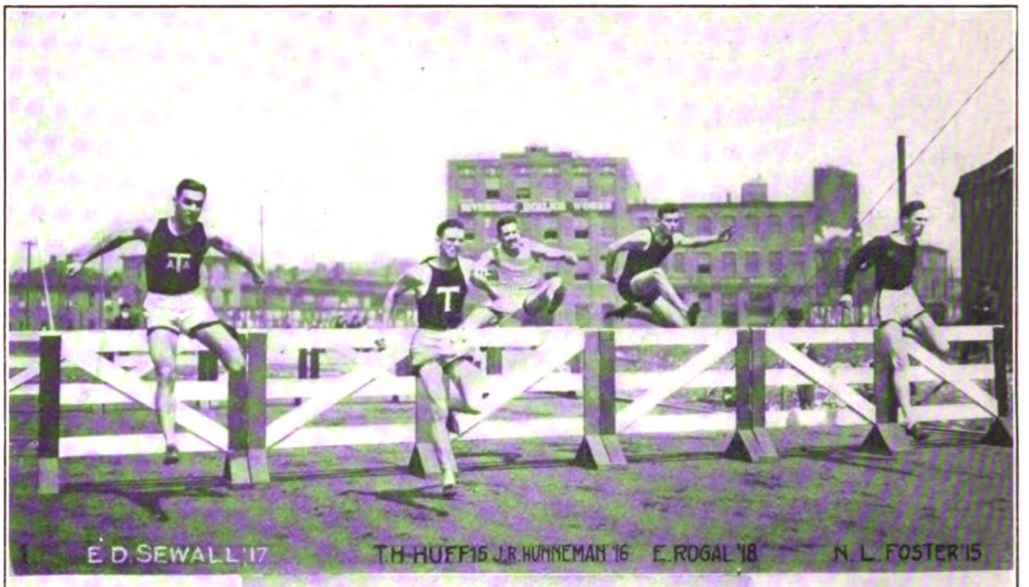
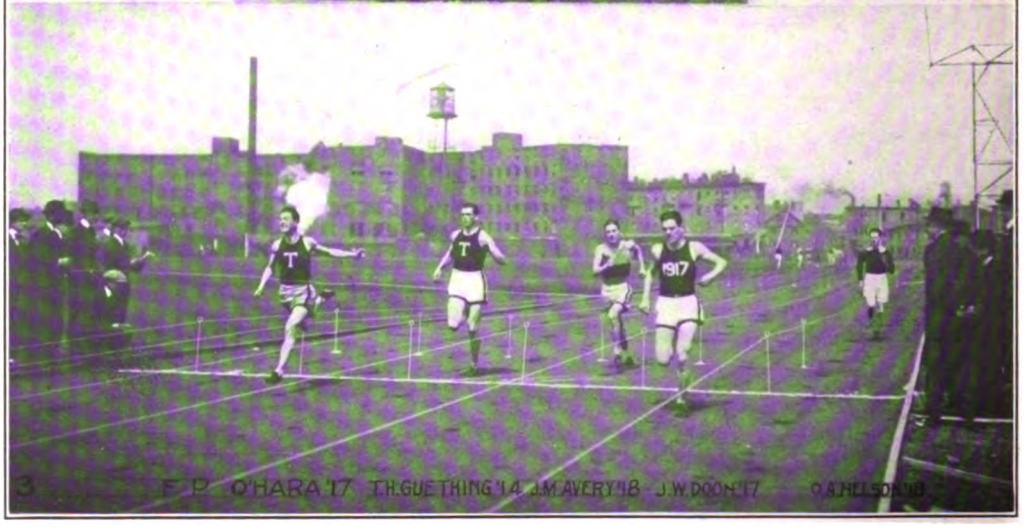


THE SPRING MEET

① HUFF WINNING THE 120-YARD HIGH HURDLES

② LAWRASON WINNING THE POLE VAULT

③ DOON WINNING SECOND HEAT 100-YARD DASH



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THE PART A TECHNOLOGY GRADUATE WOULD PLAY IN TIME OF WAR

By C. H. M. ROBERTS, M. I. T., '17

Local Secretary the National Reserve Corps
Lieut. M. I. T. Cadet Regiment

THE question has been frequently asked in the past, and no doubt will be in the future, as to what part a Technology man would play in time of war. It is the purpose of this article to show the need of a modern army for trained officers and to point out the places for which Technology men would be especially fitted in case they should offer their services in time of war.

Last year when a conflict with Mexico seemed certain, there was considerable interest among the students in regard to the forming of a volunteer organization, which was to assist in subduing Mexico. Several other colleges, notably Yale and Harvard, went about the raising of volunteer companies. The patriotic spirit shown in the preliminary organization of these forces was, of course, very commendable. It was a mistaken appreciation of the needs of the country, however, which was the basis of the movement. A large number of college men, a class which forms the most highly educated portion of our citizens, proposed to go to the defense of the country, for the most part as private soldiers. In the exuberance of their patriotism they completely lost sight of two facts. First, the country was in no need of their services, the regular and militia forces being ample to handle the situation. Second, by planning to go to the front as enlisted men, they were deliberately depriving the nation of the opportunity to use them as officers, in places where full advantage could be taken of the specialized educations which they possess.

The college man has no place in the ranks. His education has been of such a nature as to enable him to command men and by enlisting as a private soldier he abandons all the advantages of his knowledge for the sake of getting into action and having a little excitement which his more sober and far-sighted brothers forego. The condition is analogous to that of using a high power turbine for pumping water into a hundred gallon tank when a "one lung" gas

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engine would do the trick just as satisfactorily. In both cases it is nothing but a shameful waste of power. No one would think for a minute of using a turbine for the purpose indicated. Why should the college man be eager for the opportunity of using his abilities in a position far below his proper level? In the first place he looks forward to excitement and possibly the chance of distinguishing himself. In the second his education has shown him that the safety of the country depends on the readiness of its citizens to answer the call for volunteers. The college man, by reason of his education, possesses a highly develveloped sense of responsibility and hence feels that by not enlisting at once he is failing in one of the most important duties which fall upon citizens, namely, that of defending the country's position as a sovereign power. He is mistaken, however, for the records of our past wars show that just before and after the outbreak of a war the need is not for enlisted men but for highly trained officers to lead them. This condition was clearly demonstrated at the outbreak of the Spanish War. Thousands of men enlisted but could not be properly organized and drilled because of the lack of officers who knew their business. The consequence was that, without getting within hundreds of miles of the battlefield, the men died by the scores in camp, due to the fact that the officers did not know how to take care of them.

BRIDGE BUILDING

In a country such as the United States, which depends for its peace and immunity from attack by foreign powers not upon the size and strength of its standing army and navy, but upon the continuance of amicable relations

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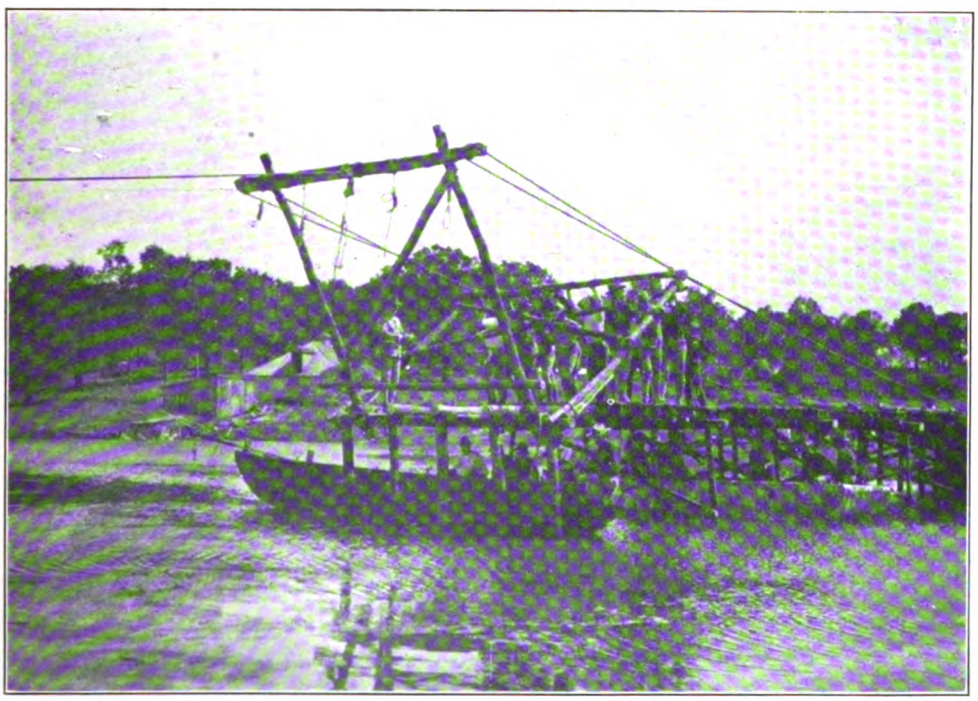
with those powers, there is the ever present possibility of war. Relations between countries are so nicely balanced that even a minor and apparently trifling incident may suffice to precipitate a bitter and bloody war; the more bitter because of the previously existing peaceful relations, the more bloody because of the Satanic perfection of instruments for the wholesale destruction of life. In such an extremity, the country looks to the men, who have had the benefits of higher education and the opportunity to organize and lead men, to step forward and take their proper places. The nation needs men to lead, not men to be led.

From college graduates many officers would be drawn and among college men the preference would naturally be given



BRIDGE BUILDING

the face of the possibilities and realities of modern warfare it becomes all the more desirable to keep the peace of this country undisturbed. In case of war, however, we have no enormous, organized, regular army upon which to depend for the safety of the nation. We must place our trust in volunteer troops composed of men who are for the most part untrained, and officered by men who may not be at all fitted for their positions of responsibility. In to those having had military training. In other words, the graduates of land grant colleges would be preferred, since they would have had military training of a kind and amount satisfactory to the War Department. The Institute of Technology is such an institution and being an engineering school, its graduates would be of exceptional value as officers in the more technical and highly specialized branches of the service, such as the engineers, signal corps, and the

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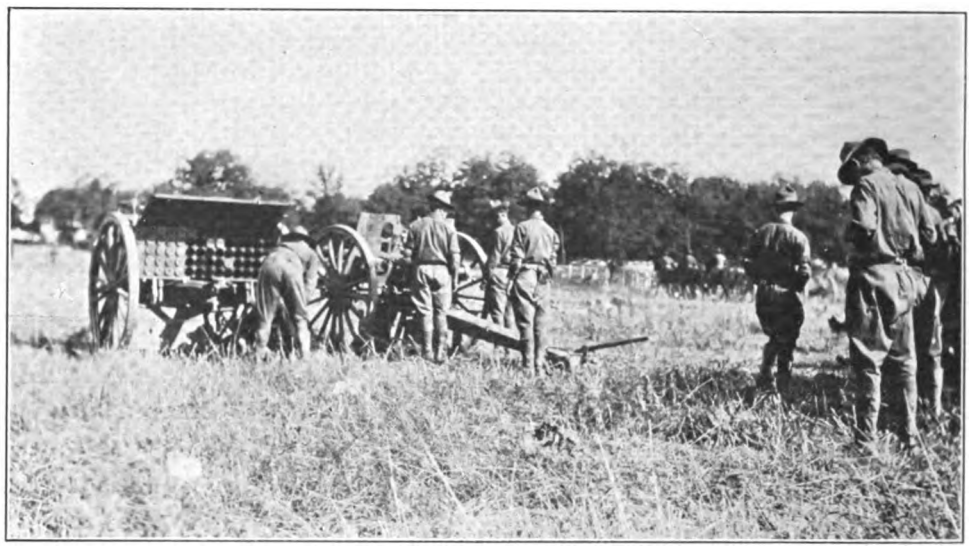

ARTILLERY DRILL

coast and field artillery. In these branches it is absolutely necessary to have officers of engineering ability and technical knowledge. Their duties are of a kind in which they cannot become proficient without special technical training and considerable experience in engineering and scientific work.

At a school like Technology men are taught primarily engineering. As a part of the engineering work and valuable from many standpoints, a course in military training is included. This course is prescribed by the War Department, is directed by a regular army officer, and the degree of proficiency attained is noted in yearly inspections by specially detailed officers. The course is neither difficult nor long, for two reasons: First, elementary military science is little more than applied common sense and as such presents no difficulties to the average college man. Second, the course is the minimum allowed by the War Department, having been cut down because of the great similarity between the West Point curriculum and that of Technology. In the first year, military training is required; in the higher years it is optional, but all through the college course and after graduation the principles of organization and discipline, applicable equally well to civilian and military work, are found of value. It is not the knowledge of how to execute right-shoulder-arms which makes a Technology man valuable as an army officer, but his technical knowledge, ability to organize and lead men, and his familiarity with the methods of study which enable him to acquire a maximum of knowledge in a minimum of time.

For its own sake, aside from the physical benefits derived, the drill of the cadet regiment is not an essential part of a graduate's qualification for commissioned rank in the army in time of war. Very little knowledge of tactics, as the man learned it, remains after a few years and what he does remember is both inexact and antiquated. Hence the value of the Institute military training does not lie in the actual, lasting knowledge imparted to the man. The natural question is, then, where does the

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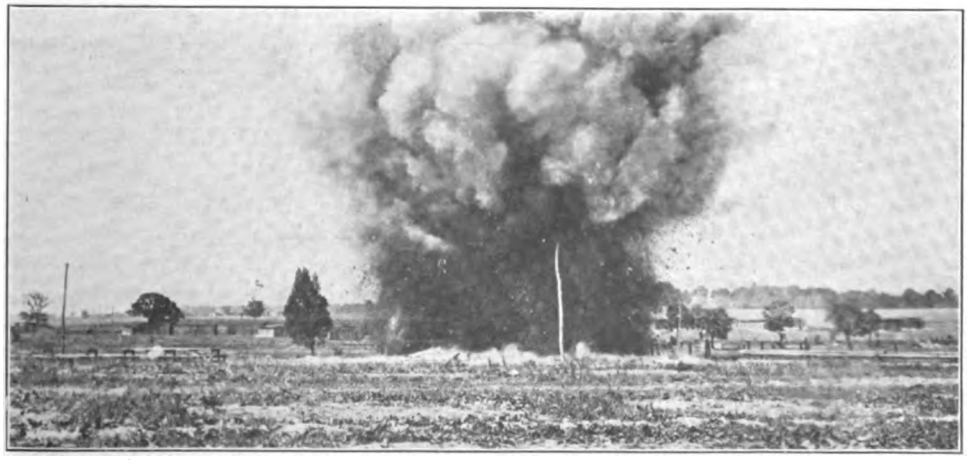
value of our military course lie? The course does not aim to turn out finished soldiers or military geniuses but rather, to afford an adequate idea of the methods by which military knowledge is attained. The object is to give a foundation in military work, upon which the superstructure may be built at any time. If the foundation is laid as a part of the man's regular college course, it becomes a part of his education and is stable. If the foundation consists of a hurried survey of military work, it is sure to be superficial, and like all superficial work, will collapse when it is most needed. In the intensive work, which officers are called upon to perform in the organization and training of troops in time of war, there is no time to bother with the rudiments. If the officers do not know how to get things started, the chances of bringing the work to a successful conclusion are few and their efforts act as a check rather than as an aid in the general plan.

One very important phase of the military work at Technology, as at any institution having military drill, is that the men acting as officers have the opportunity of organizing and drilling the companies. In this work they are obliged to take a prominent place and upon their self-reliance and self-possession depends the success of their respective companies. The men who act as officers have to know their business and then must be able to impart their knowledge to other men in an intelligible, convincing manner. Starting with the lowest non-commissioned officer and working up to the colonel of the regiment, every man whose duty it is to instruct, must be able to do so with certainty and without hesitation or self-consciousness. In other words, he must develop the prime requisites of an officer---knowledge, self-possession, and self-reliance.

The specific lines along which Institute training fits a graduate for a position as an officer, are many. Quite naturally one first thinks of the engineer corps. Its officers are all highly trained engineers, familiar with the construction and maintenance of railroad systems, with road and bridge building, with the use of explosives, and so forth. Course One men have much in common with the engineer officer. They are accustomed to map making, bridge building, and civil engineering work in



EXPLOSION OF MINE

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general. A Civil Engineering graduate, obtaining an engineer commission, would have practically nothing to learn except the one vital fact that seconds may mean life or death and that painful accuracy of detail is not essential, providing the work serves its purpose as originally intended. The duty of the engineer officer is to be prepared to do anything in the way of construction, maintenance, or demolition which is necessary to the success of a campaign. The problems he must face are essentially the same as an engineer meets every day in civilian work, with the notable exception that the facilities and time for doing the work are far more limited than they would be in civilian life.

The Mechanical Engineering graduate has much the same field in army work as the civil engineer, with one addition. His more extended knowledge of machinery makes him an exceptionally valuable man for the coast and field artillery. In the former work, especially, the problems which are encountered are essentially those of the mechanical engineer. The care and upkeep of the intricate mechanism of the coast defense guns is a problem which must be turned over to an expert, of whom many would be necessary in the event of a war involving this country.

The Electrical engineer has a wide range of usefulness in the army. The Signal Corps would claim his especial attention. In the work of that arm of the service he would be perfectly familiar, for batteries, generators, searchlights, and the other instruments commonly used by electrical engineers are employed in this work. With visual signalling, he could soon familiarize himself, as the code used in the same as for telegraphy. In the general problems confronting the Signal Corps officer very little would be demanded of him with which, as an Institute graduate, he would be unfamiliar. In details and short methods only would he find it necessary to do any studying.

The graduate in Electrochemistry would find his proper place in either the Engineers' or Signal Corps, since his

THE FIELD PACK SET IN ACTION

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work does not differ essentially from that of the electrical engineer.

The Course Fifteen graduate, at first sight, may seem to be rather useless to an army in the field. A little reflection, however, will show that his place is in the Quartermaster Corps. In that department the problems of administration and supply which he would be called upon to solve would be of the same kind as those confronting any large and active organization.

So far no mention has been made of the Naval Architecture graduate. The reason is quite obvious, as the place of the naval architect is with the navy, if he would use his special technical knowledge to best advantage.

The openings mentioned are along the more obvious and important lines in which Technology men could serve their country in time of war. If none of the branches of the service mentioned appeal to the aspirant for a commission he should not conclude, however, that his services as an officer are not needed. Officers of every branch of the service must of necessity be fairly well versed in all branches of the military profession, since the exigencies of military work make it not only possible but highly probable that sooner or later a situation will arise in which it is necessary for the man present to handle it alone. Hence it is necessary for infantry officers to know the duties of engineer troops, for cavalry to act as infantry, and so on, for all possible combinations. From this it is evident that every officer must have a greater or less amount of technical education and must be able to use it on occasion.

TRENCH DIGGING

The Technology graduate is, then, a person of some value to the country in time of war. He is fitted by education and training to be an officer. His line of education has given him the self-possession, self-reliance, and knowledge to organize, train, and lead troops in the field. By enlisting as a private soldier, he denies to his country the use of the ability which he possesses and uselessly sacrifices his life without making an adequate return for the education which he has received. The place of the Technology graduate is distinctly not in the ranks. It is his right, as well as his duty, to become an officer and as such he is of distinct value to the service.

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THE TEACHING OF THERMODYNAMICS

VI

COSMIC EQUILIBRIUM
EMPIRICAL CORROBORATIONS

By PROFESSOR SIDNEY ARMOR REEVE, M. E.

Editorial Note. This is the last chapter of Professor Reeve's series of articles on Thermodynamic subjects, which have been published consecutively in the Technology Monthly and Harvard Engineering Journal beginning with January 1915, Volume I, No. 6.

THE condition of matter discussed in the last chapter furnishes a new and most interesting pathway toward the rational concept of the absolute zero of temperature. The ordinary approach is by the imaginary cooling of gas under constant pressure, whereby its volume is reduced. When this volume shall have become zero, it is said, the temperature must be zero. But this volumetric rate of contraction is interrupted, by the condensation of the gas into liquid, long before absolute zero is reached; and while different gases condense at different margins above zero, it is impossible to escape the conclusion that even the most "perfect" gas must exhibit such a margin. And after condensation all volumetric foundation for an absolute zero is gone.

But the true scale of temperature, we have seen, is one of *work*, not of thermal conduction. If the absolute zero is ever to be reached, or even accurately predicted, it must be by the abstraction of work. But the abstraction of work from a gas must reduce its eccentricity of molecular orbit, while increasing its molecular volume or its radius D of mean energetic condition. If this abstraction could ever be complete (which it cannot) there would result a substance of pure circularity of internal motion, but of infinite volume and attenuation, and of infinitesimal pressure. The temperature would be absolutely zero, but the volume infinite. This is the exact opposite of the ordinary imaginary aspect of matter at absolute zero of temperature, but it is more accurately founded upon nature. Either concept of matter without temperature, it is to be noted, concerns an unattainable mathematical limit of condition, rather than anything possible or natural.

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It is impossible to give here more than a suggestion of the many and varied ways in which this more accurate approach to the idea of heat, by a more accurate and thorough grounding in mechanics than at present, opens doorways of illustration from nature to aid the imagination. Some of these I tried to suggest in my book: "Energy." Others will occur to every instructor who dares to set out with his students along this road. The only thing remaining to be said here is to show that the laboratory workers, as well as the merely deductive reasoners, are being forced by their daily work into progress toward these same general conclusions as to the physical reality of entropy, and as to its identity with ordinary mass, which are enforced upon any student who once starts out equipped with a true or Newtonian cosmic mechanics.

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The year 1912 brought out two notable expressions of opinion as to generalizations regarding matter and energy, from authorities in the experimental field than whom there is no higher. One of these was Professor Soddy's little book: "Matter and Energy." The other was Professor Callendar's address as President of the British Association, at its Dundee meeting, which engineers may find reported in "Engineering" for Oct. 4th of that year. I do not wish to convey the idea that either of these authorities countenances all that I have already said here. But the following quotations will show, first, that they stand for a much livelier and broader teaching of the concepts of matter and energy than is now current in our engineering colleges, and second, that one at least identifies heat and entropy pretty closely with ordinary mass, while they both accept it as beyond question that electrical energy consists of the relative motion of mass-particles. If the last be so then electrical phenomena *must* fall in line with the Kepler-Newton facts as to conic-sectional orbits, the only known true mechanics of mass and motion.

Professor Soddy says:

"Physical science enjoys the distinction of being the most fundamental of the experimental sciences, and its laws are obeyed universally, so far as is known, not merely by inanimate things, but also by living organisms, in their minutest parts, as single individuals, and also as whole communities. * * The laws expressing the relations between matter and energy * * control, in the last resort, the rise or fall of political systems, the freedom or bondage of nations, the movements of commerce or industry, the origin of wealth or poverty, and the general physical welfare of the race. If this has been too imperfectly recognized in the past there is no excuse, now that these physical laws have become incorporated into everyday habits of thought, for neglecting to consider them first in questions relating to the future."

This view I wish to support most cordially. I have long endeavored to awaken the engineering profession to a realization that neglect of its own familiar laws as to impact, friction, instability, etc., applied to social problems makes impending a gigantic upheaval. Professor Soddy aims his cautions chiefly against the waste of natural sources of energy—enlisting in what is known in America as the "conservation" movement—whereas what I condemn is the rapidly increasing social impact and friction called business. Yet what he says indicates more that, in view of radioactive sources, it is likely that new sources of energy will be discovered before the old are gone, however foolish waste may be. Professor Soddy continues:

"The upward progress of the race has been classified into succeeding eras, each designated by the name of a material. Thus are distinguished the Stone Age, the Bronze Age, the Iron Age, and the Steel Age. * * Yet, when the early records of these eras are examined, little or nothing is found about the pioneers whose knowledge and craft effected these broad advances. Often they were held in contempt. * * To come to more recent times, how many people blessed with a liberal education would be at a loss if asked off-hand what steel is? * * This is the Age of Energy, or rather this is the beginning of the ages of energy, the Age of the Energy of Coal.

"Mere accumulations of knowledge, sifted, classified, and reduced to their final most concise expression in a series of textbooks, are little more than the sepulchral monument of science. However complete and accurate, mere knowledge deadens rather than develops the intellect. * * A problem solved is dead. A world without problems to be solved would be devoid of

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science though it might be full of scientific textbooks and dictionaries."

In this hurried utilitarian age of ours there is many a teacher of engineering who, because of his failure to appreciate the truth of the above, because of his narrow addiction to rehearsing textbook statements, or to the mere multiplication of applied problems instead of concentration upon *basic concepts*, is doing his little share in leading his profession, and the entire civilization resting upon it, into a crisis. It is not the purpose of this present paper to enter into these broader questions of society; but since so able a man as Soddy has pointed out the inherent identity between study of material energy and study of social energy, as a text for preaching the importance of educating young men in both at once, that attitude will be strongly commended here.

Today is the Age, not of Coal, nor of Steel, nor of Electricity, primarily. Those Ages are yet to come. This is the Age of Human Relationships. This age deals with masses of men. Our work is done by regiments or armies of men, where a generation ago individuals sufficed. We live in a single community of a billion souls, more effectively united for mutual interaction by railroads, steamships, cables, wireless, and commercial exchange than was any million persons of a century ago. It is only sixty years since Commodore Perry opened the first Japanese port to the western world, yet today men in New York, London, South Africa, and Manchuria make and read each other's daily news, pay and get each other's prices, and suffer or rejoice in consequence of each other's acts.

The potential energy latent in any such vast community, either for production or destruction, is enormous. The possible fruits of such a gigantic fund of internal energy were suggested by the world-prosperity of a few years ago. Its capacity for sudden and violent self-destruction became visible in the single week spanning the first of last August. But, most important of all, its immanent faculty for gradual rheumatic paralysis, by internal auto-intoxication with commercial impact and friction while yet the outward form remains robust, has been only hinted, as yet, by the slow numbing of business during the past eight years.

All of these social energies, whether constructive or destructive or dissipative, are questions of human *relationships*. The four hundred million Chinese, for instance, possess individually, great industry, skill, and art; but the nation lags behind because these faculties are not brought out into useful interaction by any proper *economic organization*. It is *between* component particles, not *in* them, that energy arises or disappears. Human energy is one with all other cosmic energies, in its nature. Quite aside from any question of excitation of the individual by ambition, honesty, etc., the creation of both the excitation and its fruits rests primarily upon the character of *relationships* established between man and man by law and public opinion.

These things must be understood by our young men, else they are not educated. Our young engineers, above all other classes, must grasp them. The vast problem with which they must wrestle in the near future is not how to build turbines, armatures, or aeroplanes, but how to organize hundreds of millions of men so that their natural antagonisms shall not so paralyze all credit and exchange that the building of turbines, etc., shall have ceased. For this they are educated, so far as the natural sciences go, only when they understand thoroughly (1) that all forms of energy

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are merely different aspects of a common basic unity, (2) that all of these divers forms of energy are embodied in mere *relationships* of space or motion *between* component parts none of which exhibits the attributes of the relationship, and (3) the fundamental contrasts between useful work-performance, on the one hand, and dissipative impact and friction on the other. From the elementary Newtonian mass-pair to the complete science of sociodynamics may be a far cry; but certainly the student will never arrive at the latter, as his destination, unless he starts from the former.

EMPIRICAL CORROBORATIONS

Professor Callendar's address, in contrast with Dr. Soddy's book, deals more with details, yet it still treats them broadly, and it is even more closely aligned with what has been urged here. It teems with expression of the inadequacy of the ordinary ideas of heat and work. It is entitled "The Nature of Heat" and carries the discussion directly back to "Carnot and Caloric." For Carnot, it will be remembered, when he announced his still unshaken principles of thermodynamic action, did not commit himself as to whether heat were matter or energy. He did well, considering that not yet have we succeeded, in ninety years, in defining either matter or energy. Professor Callendar set out to consider the fundamental ideas relating to the nature of heat, and to suggest that some of the ideas of the old caloric or material theory of heat, which had so long been discredited, might with advantage be imported into modern theory. This, he felt, might appear as a retrograde step, because the caloric theory was generally represented as being fundamentally opposed to the kinetic theory and to the law of the conservation of energy. He announced an attempt to show that this antagonism was fictitious and without foundation. He said:

"Since Carnot's principle was adopted without material modification into the mechanical theory of heat, it was inevable that Carnot's caloric, and his solution for the work done in a finite cycle, should sooner or later be rediscovered. Caloric reappeared as the 'thermodynamic function' of Rankine and as the 'equivalence value of a transformation' in the equations of Clausius; but it was regarded rather as the quotient of heat-energy by temperature than as possessing any special physical significance. At a later date, when its importance was more fully recognized, Clausius gave it the name of 'entropy'. * * Equivalent propositions * * had previously been made by Lord Kelvin in terms of the dissipation of available energy. But, since Carnot's solution had been overlooked, no one at the time seems to have realized that entropy was simply Carnot's caloric under another name, that heat could be measured otherwise than as energy, and that *the increase in entropy* * * *was the most appropriate measure of the quantity of heat generated.* Energy * * must always be associated with something of a material nature acting as a carrier, and there is no reason to believe that heat-energy is any exception to this rule. The tendency of the kinetic theory has always been to regard entropy as a purely abstract mathematical function * * having no physical existence. * * In a similar way, some twenty years ago, the view was commonly held that electric phenomena were due merely to strains in the ether, and that the electric fluids had no existence except as a convenient means of mathematical expression. Recent discoveries have enabled us to form a more concrete conception of a charge of electricity, which has proved invaluable as guide to research. * *

"It has generally been admitted in recent years that some independent measure of heat-quantity as opposed to heat-energy is required, but opinions have differed widely with regard to the

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adoption of entropy as the quantity-factor of heat. Many of these objections have been felt rather than explicitly stated, and * * the answer to the question 'what is caloric?' must necessarily be of a somewhat speculative nature; but it is so necessary for the experimentalist to reason by analogy from the seen to the unseen that *almost any answer, however crude, is better than none at all.*

"The fundamental property of caloric, that its total quantity cannot be diminished by any known process and that it is not energy but merely the carrier of energy, is most simply represented in thought by imagining it to consist of some indestructible form of matter. The further property, that it is always generated in any turbulent or irreversible process, appears at first sight to conflict with this idea, because it is difficult to see how anything indestructible can be so easily generated. * * * The caloric may have existed previously in a form in which its presence could not be detected. In the light of recent discoveries we might suppose the caloric generated *to arise from the disintegration of the atoms of matter*. No doubt some caloric is produced in this way. * * " (Italics mine.)

This is precisely the method of generation of entropy which is pointed inevitably by the mechanical theory of heat, when founded upon true mechanics. And so far as purely thermal phenomena are concerned, there is no difficulty in regarding all entropy as produced in this way.

The bulk of Professor Callendar's address teems with discussion of electrical phenomena in terms of caloric or entropy. These lie largely outside our present province. But since I wish to emphasize the importance to engineering students of keeping ever before them the *unity* of the several forms of energy—mechanical, thermal, electrical, and chemical, at least—presented by competent instructors in each of these branches, working in harmony, and since there seems to be great reluctance, at present, to anything else than a narrow, exclusive method of portraying each energy as independent of all the rest, the following quotation from Professor Callendar may be reassuring. For whereas there is some slight readiness to regard heat as really mechanical (whereupon entropy must be mass), the average instructor seems quite afraid to teach that electricity is only mechanical or thermal energy disguised.

"The earliest measurement of the relative conducting powers of the metals for heat and electricity showed that the ratio of the thermal to the electric conductivity was nearly the same for all the pure metals and suggested that, in this case, the *carriers of heat and electricity were the same.* Later and more accurate experiments showed that the ratio of the conductivities was not constant, but varied nearly as the absolute temperature. At first sight this might appear to suggest a radical difference between the two conductivities; but it results merely from the fact that heat is measured as energy in the definition of thermal conductivity, whereas electricity is measured as a quantity of fluid. If thermal conductivity were defined in terms of caloric or thermal fluid [or of entropy or thermal mass], the ratio of the two conductivities would be constant with respect to temperature, almost, if not quite, within the limits of error of experiment. On the hypothesis that the carriers are the same for electricity and heat * * it becomes possible * * to calculate the actual value of the ratio of conductivities. The value thus found agrees closely in magnitude with that given by experiment. * *

"If I may be allowed to speculate a little on my own account, * * I should prefer to regard the molecules of caloric, not as being identical with the corpuscles of negative electricity, but as being neutral doublets formed by the union of a positive and negative corpuscle, in much the same

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way as a molecule of hydrogen is formed by the union of two atoms." (Italics and bracket mine.)

To the above add the following quotation from Professor Soddy's "Matter and Energy":

"Electrons are a normal constituent of matter, and are found revolving round the atoms much as the planets of a solar system do around the central sun. The electrical tractation between the electron and the positively charged atom takes the place of gravitation. The electrons, like the planets, possess a period of revolution appropriate to their distance from the atom. The nearer they are the faster they must revolve, the law regulating the period of revolution and diameter of the orbit being completely analogous to Kepler's law for the planets. But owing to the minuteness of the atom and the relative greatness of the electrical tractation compared with gravitation, the periods of revolution of electrons are almost inconceivably short. These electrons revolve thousands of millions of millions of times per second, so that it might be supposed that it would be quite impossible to measure them. As a matter of fact, no magnitudes in science are known with greater exactitude."

Compare with this the language of D'Arsonval in his address at the close of the first International Cold-Congress in Paris, Oct. 12, 1908, as quoted in *La Nature* for May 18, 1912:

"The intimate constitution of matter and the nature of electricity may be revealed to us in a study of them in the neighborhood of absolute zero. The discoveries brought about by the work of Curie, J. J. Thomson, and Rutherford show us the atom as a tiny solar system. It is made up of a fantastic rotation of electric corpuscles, in which, despite their smallness, are stored active forces millions of times greater than the energy of our most violent chemical reactions.

"Thus, in the hydrogen atom * * * there are a thousand of the corpuscles called electrons, charged with negative electricity and gravitating about a positively charged nucleus. These electrons are separated from one another by distances comparable, having in view their own dimensions, to those of the planets in the solar system; they revolve about one another and about the nucleus with extreme rapidity (many millions of times a second). From this extraordinary activity arises the formidable energy stored in the invisible dust-speck which we call the atom. Lodge tries to give an idea of it by saying that in one gram of hydrogen there is enough energy to lift the whole British fleet to the top of the highest mountain in Scotland.

"Now we can, by bringing into action powerful magnetic fields, change the orbits traversed by the electrons, get at these wonderful corpuscles in this way, and by modifying the atomic solar system, make the preceding conditions more definite." (Translation by *Literary Digest.*)

Compare with this also the views of Sir Ernest Rutherford, as summarized by Popular Science Monthly for June, 1914:

"Rutherford * * has developed a theory of nuclear atoms according to which a central nucleus of extremely high potential is surrounded by negative electrons whose motion it controls. If so, the electrons are controlled by the nucleus *very much as the planets are held* by the solar system by gravitation, and indeed there appears strong reason to suppose that the force involved is really inversely proportional to the square of the distance, as in the case of gravitation."

Another version of Sir Ernest's views was given by him at the Australian meeting of the British Association in August, 1914, in connection with the joint discussion of Sections A and B on "The Structure of Atoms and Molecules." The following is quoted from the report thereof given by (London) Engineering for Nov. 20, 1914:

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"It was remarkable, Sir Oliver Lodge said in his introductory remarks, that such a discussion should be possible. In the past century the atom had been something devoid of constitution; now an *astronomy* of the atom was being developed. Whether the law of inverse squares really held for the particles of the atom revolving around a central nucleus was not clear * *.

"Sir Ernest Rutherford, F. R. S., in opening the discussion, remarked, '* * * There was convincing evidence of the independent existence of the atoms, which could be counted, and the atomic theory had now to be regarded as a proved fact. The mass of the atom had been determined within a few per cent by several methods. The idea of the atom being an electric structure had arisen early. The electron must be one of the component parts of the atom for various reasons, and one point was of fundamental importance: the unit nature of negative electricity'. * * He believed also in a unit of positive electricity. * * His own theory of the atom was that the positive electricity was not diffused, but concentrated in a central *nucleus*, which was surrounded by rings of electrons; * * the electrons were at relatively enormous distances from the nucleus. * * A high-speed Alpha-particle entering the matter passed through it, being repelled by the nucleus, and was *deflected on a hyperbolic path*; these paths had been studied by Geiger, Marsden, and himself, and they were *compatible with the law of inverse squares*, to which he would adhere as long as he could." (Italics mine.)

Naturally! Since the law of inverse squares is the *only* law ever yet revealed to scientific investigation, as the basis for that work with which both heat and electricity long ago proved themselves interchangeable, why should any scientific mind gratuitously confuse itself by assuming the existence of any other? There has never arisen an atom of evidence that there was any other law.

Yet, however interesting this may be to find thermomechanical conclusions verified by electrical ones, this nuclear hypothesis is, as has been shown above, an old story in thermics. It has been imposed inevitably, for at least thirty years, upon every teacher who has been unwilling to reject the conclusions of Kepler, Newton, LaPlace, Rumford, Carnot, Clausius, Joule, and Kelvin. Even in engineering thermodynamics its cogency has been recognized. In the writer's book, "Energy," written before 1908, nine pages are devoted to the nuclear explanation of the thermal molecule, the word *nucleus* being italicized and a diagram given showing two molecular nuclei exchanging pressure by means of their satellites.

"In the Harvard Engineering Journal for January, 1908, and again in the issue for November, 1908, the doctrine of the astronomical structure of the atom, with entropy in the form of satellites about a central nucleus massively embodying heat, was clearly set forth. This view as to heat was as rigidly enforced by the thermal empirics available thirty years ago as the same doctrine as to electricity is compelled by the electrical empirics of the last decade."

In view of the above statements, and of their origins, it would seem a most gratuitous task to urge that Newtonian celestial mechanics should be taught in every technical college. Yet so true is it that a great gap exists here in our scientific edifice that it is almost impossible for a student to learn elementary Newtonian mechanics even when he sets out to do so. For there exists, I believe, not a single textbook of college mechanics or physics which presents the topic, not even the astronomies give it in assimilable form, very few teachers are acquainted with it, and virtually no educated engineers know that such a thing exists. Here is the

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foundation for understanding all of the energetic sciences, and not a student thereof is either guided or aided toward a grasp of it! Yet prating of devotion to "fundamental principles" is rife! Most teachers do not know the meaning of the term.

Does this language appear stronger than is justified by the facts? Listen to the following quotation, a still later corroboration of the views urged in these articles, appearing in the *Zeitschrift* of the German engineers for Nov. 1st, 1913. Pages 1751-2 are devoted to a review of "the latest aspect of the nature of energy," as developed by Professors Planck and Nernst:

"In measure of the importance of the problem and of its ancillary questions it is to be noted that, at the suggestion of the Royal Scientific Society of Göttingen, and particularly of Professor Hilbert, six physicists who have taken prominent part in the development of the new theoretical views were called to Göttingen to report upon the latest aspect of the investigation. Some days after this scientific conference (April 21-26) Professor Riecke gave a lecture at the meeting of the Göttingen Association for the Advancement of Applied Physics and Mathematics upon the relation of material atoms to energy, from which we select the following noteworthy deductions."

The ordinary idea of energy, as illustrated by a lifted weight, is first reviewed, attention being called to the facts that (1) the energy is proportional to the height, increasing indefinitely, and (2) that it is zero at the earth's surface! In later paragraphs it is pointed out that this "old-fashioned" idea of energy has been found insufficient to fit the facts developed in the laboratory, in two respects. The first respect concerns radiation.

The general facts of radiation are next recalled: How a body of low temperature emits radiation of long wavelengths, a hotter body shorter wavelengths, etc. But this situation, under attempted reduction to exact mathematical formulation, shows complete failure. To dodge this trouble Planck has offered the "bold hypothesis" that energy does not increase continuously in matter, but that matter contains definite quantities of energy! Thus:

"Imagine an atom of a certain number of vibrations. According to Planck this atom can absorb energy not in continuously varying quantities but only in certain definite proportions, depending upon its vibration-number. The atom can then absorb one such quantity, or a second, or a third, but never a fraction thereof."

It seems a pity that the fact that this "bold hypothesis" was nothing more than what was known since Newton's day, or since La Place at the latest, should not have been stated at this point. For, according to Newton's law of gravitation, the energy stored in a lifted weight is *not* proportional to the height of elevation; nor is it indefinite in amount. The energy per unit of distance of lift decreases as the square of the distance increases, and obviously soon must become negligible at distances of appreciably large multiples of the earth's radius. The mathematical limit to the storage of energy in a mass M_1 relatively to another mass M_2, such as the earth, which can in fact never quite be attained in nature, is

$$E_{max}=cM_1M_2\frac{1}{R}$$

wherein R is the earth's radius in feet and c the constant of gravitation, or the reciprocal of 29 or 30 millions.

This quantity depends primarily upon the minimum distance R of approach between the two masses, and this, in turn, depends upon the velocity or period

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of revolution. The fact that, in the case of an atom of stated period, the energy brought in by particles from a distance which is large in comparison with the atom's dimensions, the quantity per particle is fixed, and is dependent upon the atom's velocity of vibration, are the only facts which could be deduced from the hypothesis that such atomic action followed the laws of true Newtonian mechanics. This should certainly have been stated.

"But with this [Planck's] assumption the continuity and the equal distribution of energy are abolished. If a body be imagined formed of atoms of different vibration-numbers, each atom must have a different capacity for absorption of energy. The atoms of quickest movement correspond to the largest energy-quantities; the mouthfuls in which the energy is swallowed are larger with them than with the more slowly moving atoms.

"Now the rapidity of vibration depends upon the force with which the atom is held in its place. The greater the force the more rapid the vibrations. Likewise, also, the greater the difficulty with which any external disturbing cause removes it from equilibrium, the greater this force may be. Thus, *the firmer an atom's position the greater is the quantity of energy it can take up.* Equality between the atoms is thus abolished, and of the general fund of energy those atoms take the major portions which are fixed in place with the greatest force.

"From this peculiar and novel conception Planck is able to deduce a law of radiation which coincides completely with the empirical, and this warrants further novel imaginings in opposition to earlier results.

"But in another way also the new concept has proven itself brilliantly. The Dulong and Petit law can be stated as follows: The atomic heat of all elementary bodies is the same. But carbon, with an atomic heat of about one-third that of the majority of solid elements, has always formed an exception to this law. This exception has been put off upon the dependence of atomic heat upon temperature, The atomic heat of carbon at ordinary temperatures is slight; but it grows with rising temperature, and at temperatures above 1800 F. approaches a fixed limit which harmonizes with the Dulong and Petit law.

"Nernst's great service has been to show that this peculiarity of carbon in no wise forms an exception, but illustrates the generality of the law. The atomic heats of all bodies decrease with falling temperature, but the decrease becomes noticeable with most bodies only at temperatures far below zero, such as are attainable only by means of liquid air, hydrogen, and helium. Such a variation of atomic heat is inconsistent with the older assumption of equal distribution of energy and becomes comprehensible only when one proceeds from the idea of definite energy-quantities. The dependence of atomic heat upon temperature deduced from this notion agrees completely with the results of experiment.

* * *

"The well-joined structure of the older physics is smashed by the new knowledge, and the foundations thereof appear no longer as truths of unlimited applicability. * * This transition period in which physical concepts find themselves naturally creates many dissatisfactions. *There is lacking a bridge between the old propositions of mechanics, whose usefulness in application to a wide field of phenomena cannot be doubted, and the new way of looking at things.* When an atom in vibration is competent to absorb energy only in stated quantities, how is it with the energy-absorption of an atom in constant or accelerated motion? * * These are questions to which no answer can now be given. The efforts to bridge the gap between the new concepts and the old reminds one of the proverbial new wine in old bottles. It will prove to be necessary to reform the physical picture of the universe, and in the new picture the old physical laws will receive their proper value and

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importance." (Translation and italics the author's.)

The "gap" is not perceived, except as it exists in minds uninformed as to true Newtonian mechanics. This "new" way of looking at mechanical energy was taught, as a necessary prerequisite to any comprehension of thermodynamics, fifteen years ago at least at the Worcester Polytechnic Institute. It was taught by LaPlace over a century ago. The instruction along these lines at Worcester was meagre and inadequate, it is true, because the time for it had to be stolen from that regularly allotted to thermodynamics. But it was done each year, and the concepts of energy-quantities fixed per mass in terms of the minimum distance and maximum speed of approach, and of entropy as simply mass, were furnished as alone fit for the the comprehension of work and heat. How much further they might be useful, in application to the problems of mathematical physics, the teacher was not competent to say. But certain it is that, if such childlike innocence of the truths of Newtonian mechanics as the above exists in the minds of Germany's greatest physical savants, statements can scarcely be exaggerated as to its prevalence throughout all the American engineering colleges.

Those who care to pursue this topic further are referred to papers by Dr. F. A. Lindemann, one of Nernst's collaborators at the Physikalische-Chemische Institut, Berlin, "On the Atomic Heat of Solids," and by Dr. G. E. Gibson, of Dundee, on "An Hypothesis as to the Nature of Planck's Quantum of Action," abstracted in *Engineering* for October, 1912.

The topic is unending. Enough has been said to show that the modern aspect of work, heat, and electricity, as merely allotropic forms of mechanical motion and separation between mass-particles, is a very different one from that now taught in virtually all engineering colleges. The final and overwhelming proof of this fact is now coming, it seems, from European experimental laboratories. But, so far as heat and work are concerned, all the data requisite for the recognition of entropy as a function of mass, and for recognition of the definite energy-quantum for each mass-pair, have lain ready for a generation, at least, without need for experimental proof. The natural indications have all along been that entropy was mass. The burden of proof has lain wholly with those who held that it was merely a mathematical function. It was an American mathematician, Willard Gibbs, who twenty years ago developed the fact that, even by the most mathematical of arguments, the definition of entropy worked out to something very like mass. It is to the writer inconceivable how American teachers, so commonly boastful of their freedom from slavish tradition, can have persisted so long in overlooking what has been obvious for at least three decades, or ever since the mechanical equivalent of heat became accurate knowledge and the porous-plug experiment passed the fiction of the "perfect gas" into limbo forever.

If American teachers are not to be left behind by their European competitors, they must realize promptly that the only proper medium for the presentation of the most elementary thermodynamic principles is the entropy-temperature diagram. The commercial convenience of some other diagrams, such as the "entropy-heat," the "temperature-pressure," etc., for certain engineering tasks, has misled many instructors into thinking that these diagrams are educational. They are not.

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However useful as tools they may be, they are distinctly confusing as to basic principles. The writer has not the slightest objection to their use *after* the student has acquired command of his thermodynamic principles. But to use them *before* that time hopelessly confuses the student.

In the entropy-temperature diagram the co-ordinates represent the two factors of heat. It is the only really "thermal" diagram. On its field the two basic thermodynamic processes which we have just found to be contrasted as fundamentals—the adiabatic and the isotherm—appear as straight lines, the first vertical and the second horizontal.

In the entropy-temperature diagram the Carnot cycle, discovered nearly a century ago as the basic and most efficient of all cycles, and maintaining today a still stronger position as the *only* thermodynamic cycle (all other cycles being mere mixtures of Carnot cycles with irreversible processes), appears as a simple rectangle. Just as all energy-transformations in nature are made up of Carnot cycles plus irreversible processes, so, in the entropy-temperature field, all areas measuring energy can be treated as the integrations of the elementary rectangular element: $dT\,dQ$.

It is easy to explain to the student that it is impossible ever to isolate either of these processes perfectly in nature. In the vaporization of steam under constant pressure we have a near approach to the isothermal. In the compression or expansion of air we have a close approach to a pure adiabatic. If the air were quite without viscosity, or were a "perfect" gas, and could be isolated, then the adiabatic would be "perfect" also. But I consider it of far greater importance that the student should grasp the fact that there is no such a thing in the universe as a non-viscous gas, than that he should know what a non-viscous gas would do if it did exist.

It is for these reasons that I decry the use of the words "perfect gas" at all. All science is based upon the study of the world as it is. The highest fruit of scientific teaching is the inculcation of faith in the world as it exists. It is a great error even to suggest to the youthful mind that a thing can be "perfect" by being unnatural.

It is for all these reasons that I further decry the whole customary plan of opening the subject of thermodynamics by discussing the action of a unit volume of air, as an imperfect representative of a "perfect" gas. The objection does not turn upon mere language. It is based upon the use of a *gas* as the fundamental thermodynamic illustration.

Heat exists indifferently in solid, liquid, and gaseous matter. The most familiar instance of thermal action, to the engineering student, is the formation of steam, in which gaseous flame, solid boiler-wall, and liquid water interchange heat. Or in steam-heating coils, for instance, the heat flows in the opposite direction from steam to air. These common instances make it obvious that any exposition of heat which rests upon one only of the three forms of matter, the gaseous, is incomplete and misleading. It misleads the instructor into talking about his cubic meter of air (which is *matter*) as if it were .heat (which is *motion*). It misleads the student into confusing, at the start, *gaseousness* for *heat*.

If the liquid form had been chosen as the single representative of the three states, there would be less objection; for the liquid is the central or average of the three. But to select the gaseous form, which is one extreme, as the foundation of heat is to make the argument

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one-sided from the start. Gaseousness, it is true, is closely identified with temperature; but temperature is work, not heat; wherefore this mode of entrance upon thermodynamics is again fundamentally misleading.

The only introduction to an exact and clear idea of heat is one based indifferently upon all three conditions of matter. It then becomes clear that we are talking not about the matter, but about the energetic processes occurring within it. The method outlined above does this. No choice is made between one state or the other, in the experiments or illustrations, until the adiabatic is reached. There a gas or hot liquid must be used. But as gaseousness is united with temperature, and since temperature is work, and since the adiabatic is exclusively identified with work—all three facts being fundamental thermodynamic ones which it is our aim to impress upon the student from the start—this emphasis upon gaseousness is just what is desired.

It may be replied that this is the only purpose to which the ordinary method puts its illustrative "perfect gas." True, technically. But in the ordinary method this comes *at the start*, with no underlying concept of heat given to the student. The student naturally thinks that this hot, elastic gaseousness is heat; whereas the prime aim should be to show him that it is *work*, not heat, by giving him a complete concept of heat before the adiabatic is mentioned. The simple experiments listed above, based upon impact and friction, with the immediate use of the word "entropy" and the immediate portrayal of all processes on the entropy-temperature field, I believe to be the only proper entrance to thermodynamics. It is assumed that acquaintance with the steam-table is inculcated incidentally to this method, but only so far as may be necessary to follow the experiments. The pressure-volume diagram is to be rigidly excluded. It portrays *matter* under the influence of heat, not heat; and every effort must be made to contrast matter and energy, in the student's understanding. All problems in applying heat to matter must be postponed until after the laws of heat independently of matter are understood.

The instructors of today in thermodynamics have not yet learned what Carnot stated ninety years ago, in laying a foundation which has never yet been shaken, viz: That heat-action is *independent of the particular working-substance employed.* Not all substances will work alike in a heat-engine, it is true; but if they work at all they *must* work according to the laws of heat, not according to the laws of matter. If the teachers would accept this as the fundamental guide-post to the science, and plan their entire course in accordance, nine-tenths of the present obscurity and obloquy now attached to the study of thermodynamics among undergraduates would disappear.

THE END.

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EDITORIAL SECTION

The Technology Monthly and Harvard Engineering Journal

A Magazine devoted to the interests of the Massachusetts Institute of Technology--The Official Organ of the Association of Harvard Engineers

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All manuscripts submitted for publication in the TECHNOLOGY MONTHLY AND HARVARD ENGINEERING JOURNAL should be accompanied by the writer's full name and address. Manuscripts not accepted for publication will be returned only if the author so requests. Photographs, drawings, etc., will be returned to the contributor immediately after publication.

Forms close the 28th of the month immediately preceding date of publication. Material specially arranged for may be received up to the fifth day following.

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THE NEW BOARD

THE Technology Monthly takes pleasure in announcing the selection of officers for the remainder of Volume II as follows: Edwin J. Goldstein, of Hartford, Conn., Editor-in-Chief; Raphael Alfaro, of Ahuachapam, Salvador, Central America, Business Manager; Carlos Stone Rood, Jeanesville, Pa., Managing Editor; Richard Henry Catlett, Staunton, Va., Treasurer; Joseph Henry Stagg, Bridgeport, Conn., Circulation Manager; Robert E. DeMerritt, Reading, Mass., Advertising Manager; Ralph F. F. Brooks, Roxbury, Mass., Publicity Manager; Maurice F. Brandt, Trenton, N. J., Asst. Managing Editor; Arthur M. Southwick, Waban, Mass., and Lansing McVickar, New York City, Associate Editors; William C. Cronin, Boston, Mass., and Elmer E. Legge, Brockton, Mass., Asst. Advertising Managers; Frederick H. Norton, Boston, Mass., Staff Photographer.

That same lack of internal friction which has been such a big factor in maintaining the stability of the Monthly throughout its first year and a half is certain to continue with these men who, coming as they do from many different localities, possessing widely different ideas, have worked in their minor positions with a unity of purpose and spirit of good fellowship that seldom characterizes any group of students. For their efficient and faithful work as assistants, the retiring Board wishes to express its appreciation to these men upon whom the responsibility of publication now rests.

IN CONSIDERATION OF THE COLLEGE GRADUATE

FROM time to time a little has been said of establishing a graduate department at the Institute. Just at this, the eve of the transfer to the new buildings and the extinction of the Harvard Graduate School of Engineering, it seems fitting to give an expression of one of the opinions through some abstracts from a short address given at the Annual Dinner of the Association of Harvard Engineers by Philip S. Donnell, the last president of the Association:

"Finally, my point is this: we have come to believe that there was and is a place in the world of engineering education which can be filled only by a school like the Harvard Graduate School of Applied Science. And remember, in saying this, we (the present class) are in no wise prejudiced by preconceived sentiment for Harvard, as nearly all of us come from other institutions. And this is in no wise decrying Technology, which has been a wonderful school, whose reputation I have found to be as great in far China and India as it is here. But it seems to me that the schools are for an inherently different purpose. Technology is primarily for the training of men who have just graduated, with the proper requirements, from high schools, while here was a school for those with older, maturer minds, for all of us have had a college education and many beyond that a greater or less number of years of experience either in their chosen field or another. Now for men like this who wish to continue their technical education it does not seem fitting that they be forced to have their work in common with the men who are so much younger. In the first place it is obvious that, although some do not yet admit it, added years of training and experience give to the older man a greater power of absorption of knowledge—a greater capacity to do things and accomplish more in a given time. This is of great advantage to one if conditions are such that it can be made use

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of, especially if he is getting along in years and feels that he should be out in the field of life.

"Then along with the studying together there comes to the older man a continuous feeling of unrest and discontent — a feeling that there he is with all his experience and years, doing the same work side by side with the man of nineteen or twenty. All the time his mind is reaching out to bigger and broader things than he can get within his prescribed sphere.

"Because of these things it is our hope that there will be established at the new Technology an entirely separate and distinct department to be run as a graduate school, something on the lines which have been laid down here at Harvard. Even with this separation there would still be left the greatest of the justifications for the union, viz: increased efficiency due to non-duplication of administration, apparatus, and other equipment, although of course it would necessitate a slightly larger faculty.

"Now we do not in any wise wish it to be understood that we are criticizing what has been done in the past but expressing, as strongly as may be, a sincere hope of what will be done in the future, for we realize that those who have brought it about have a larger and clearer vision of the advantages to be eventually derived from the merger than we can hope to have, who have seen it from the outside and only incompletely at that.

"We simply wish to put ourselves on record at this time, the end of the last year of the Harvard Engineering School, as believing, that there has been a place, and is and will be a place in the world of Engineering Education for just such a school as this, and even more especially for just such a school as this might have been with a few more years of growth and an unlimited opportunity for perfecting its systems and its ideals."

VACATIONLESS VACATIONS

If those who grant us occasional holidays do so merely to fulfil the requirements of law or custom, and in no sincere desire to observe holidays so set apart, the procedure is an empty ceremony. But we can hardly believe that in general such is the case.

Assignments made previously to a holiday very often include a double allotment of home work to cover the day of necessary absence. If this practice is approved by higher powers than our instructors, and indulged in by our experienced (in their own line) professors, there is, indeed, need that some sort of an understanding be reached as to just what constitutes a vacation.

Many professors are so absorbed in their own subjects that they fail to realize the existence of the other branches. Many perceive the undesirability, but seem unable to resist the temptation to make an excessive assignment over vacations in order to finish the text in a shorter period and have time, *not for a review*, but for some added topics of perhaps very little interest and less value, coming as they do at a time when the student is reorganizing what previous knowledge he has, for use in examinations.

Notwithstanding the admirable tendency to make Institute training an all-inclusive training, a compendium of expert knowledge on everything, one fact is not to be overlooked; namely, that holidays are intentional and specifically instituted as vacations not for the instructing staff alone, but for all the school.

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SHOP TALK

THIS issue of the Technology Monthly and Harvard Engineering Journal sets a new record for size, having sixty-four pages made up for the most part of illustrations.

Although even now a great deal of material is on hand for the Fall issues, the Monthly extends an invitation to the students and others to submit articles which they may have written or may write during the summer months. The forms are never finally closed until two weeks before publication, a fact which enables a more satisfactory selection of material for publication.

Arrangements for the publication in the Fall of articles, especially if accompanied by illustrations, should be made as soon as possible by communication with the Editor-in-Chief whose address is in care of the Technology Monthly and Harvard Engineering Journal, Boston, Mass.

AN APPRECIATION

WITH the present issue there passes from the Board of Editors and from the Institute one whose efforts in behalf of the publication have been greater, perhaps, than those of all others combined,—whose energy and enthusiasm have built up the magazine, and who leaves it, in the second year of its existence, on a sound basis.

KENNETH DEPRÈS KAHN was the virtual founder of the Monthly. The task of organizing such a magazine at Technology had been taken up at various times before, but with unvarying results. Ideas upon the subject were ever plentiful. Yet that invisible something which was necessary to carry the magazine out of the realms of dream castles and make it a reality seemed on each trial to be missing. Today the footing of this periodical is firm. And the invisible something which *has* made the magazine put in its first appearance when Mr. Kahn took charge of the work.

Although officially Editor-in-chief, actually Mr. Kahn filled to a remarkable extent all the other offices. While attending to the innumerable details incident to issuing the first numbers of the periodical he conducted with the greatest activity every duty of the usual officers, from writing editorials to securing advertisements—indeed, did the major portion of the work connected with every department of the magazine.

That the loss of Mr. Kahn's activity, willingness, and initiative will be felt by his successors goes without question. The new Board can only hope to see produced in itself that same enthusiasm, energy, and persistence which from the beginning have so characterized Mr. Kahn's work.

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HARVARD ENGINEERING SOCIETY OF NEW YORK

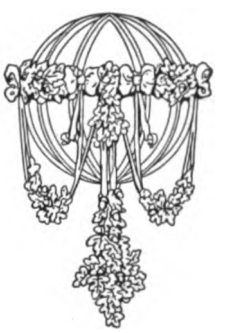
The eighth annual meeting of the Harvard Engineering Society of New York was held at the Harvard Club, Friday, April 30th, 1915. The following officers for the year 1915-16 were elected:

Clifford Richardson, '77, President,
Charles Gilman, '04, Vice President,
Clifford M. Holland, '06, Secretary,
Dean J. Edwards, '03, Treasurer,

and as members of the Executive Committee,

Warren Delane, '74,
Sidney J. Jennings, '85,
Ralph R. Rumery, '99,
J. F. Sanborn, '99,
J. P. H. Perry, '03,
R. W. Greenlaw, '02,
W. S. Nichols, '03.

Following the business meeting, the members of the Society and the Harvard Club were addressed by Fire Commissioner Robert Adamson, on the Organization of the New York Fire Department.



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LOCAL COLOR

HEARD IN MALDEN

Phyliss (from Newton, during a lull in "Getting A-Cross" performance): Some pause!

Wyliss (looking at hands and coloring): Well, I must say, Phyliss, you've got an awful nerve!!!—Ex.

WE GOT THIS ONE FROM OHIO UNIVERSITY

Professor (to tardy student): Good morning, I am glad to see you early of late; you used to be behind before, but now you are first at last.

EXPLAINED

Caesar (cutting himself)—D——!!!!* Blankety Blank!!!**

Calphurnia (without) — What ho, m'lord!

Caesar—What hoe? What hoe? Jillette, damn it! Jillette!—Chapparal.

AND THEN HE FLUNKED

Instructor (to student)—How long did it take you to prepare these notes?

Student—Why I worked all night writing them, and then I got up before daylight to study them.—Siren.

OF COURSE NOT

Gagnon (troubled): Can't you say that the ions travel through the solution according to the first theory mentioned?

Professor: Certainly; that is one method of explaining the events which take place; obviously the explanation is satisfactory, although it is not necessarily the correct one.

SPANISH GLADIATORS, GET THIS

Professor Currier: I wish to call to your attention the fact that there will be a one-hour test next week. What is wanted is a knowledge of the subject rather than superheated atmosphere.

A REASON

"Wake up, Bill, there's a fire on the Row."

"Frarority or soternity?"

"Fraternity."

"Let the damn thing burn!"—Chapparal

ELEMENTARY ORGANIC CHEMISTRY

Write reactions for 56 methods of preparing dimethyl isopropyl butyryl acetic acid and give 181 names for each. In the extremely important hiatus of elyytic stereo-isomerism of enantiomorphous substances discuss the characteristic properties of the substituents of dextrorotatory and laevorotatory isolinolinic acid. Give the Geneva nomenclature for ethyl acetate, amyl alcohol, Emil Fischer. (Three minutes will be allowed for this problem.)

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THE KALENDAR

JUNE

1. Caesar crosses the Rubicon, 49 B. C. The original Ford joke was cracked at this time.
2. Several semi-college graduates, having decided to "lay off" work and take life easy, will be engaged as physics laboratory assistants, ——Boylston Street; when?
3. Lieut. Richmond P. Hobson sinks U. S. S. Merrimac in Santiago harbor as obstacle to escape of Cervera's fleet, 1898. The Spanish are not blocked. Hobson is rescued.
4. The Chicago *Times-Post* declares that seats in Congress are more than mere tokens of reward.
5. The European case of Burgundy involves the Sforgas (the league of Cognac) in war. The forces of Constable de Bourbon capture Rome, 1527.
6. Conversation in regard to above case is recorded, 1915, by Westmin Thorndike Brewster.
7. CLASS DAY, at the exercises of which more "class" will be displayed than ever before, since Class Day of 1914.
8. GRADUATION DAY. The weather will be unusually warm on this day owing to an increase of nearly 300 degrees in Boston. (This is "deep.")

   On this day also President (then) Roosevelt took the first step in bringing about the end of the Russo-Japanese War, 1905.
9. On this day (?) President Wilson takes the first step in bringing about the end of the Great War, 191?.
10. Omar* (advertisement), a father-in-law of Mohammed, becomes caliph on the death of Abubekr, 634.
11. Ibraham Lodi of Delhi, M. I. T. '39 B. C., overcome by a Mogul (another advertisement) Baber at Panipat.
12. Mohammed forces Mecca to acknowledge his sway, 629. (adv.)
13. About this time, 1829, the first locomotive used in America was imported from England for the Carbondale & Honesdale R. R. (Pa.) The locomotive is being used at present on B. & M. commuters' trains.
14. New Institute of Technology, whose physics lecture rooms will be ventilated, approximately complete, 1927.

    Charles Goodyear patents the process of vulcanizing India Rubber, 1844.
16. On this day 132 persons will apply for information at the information bureau, so called, in Rogers. Of this number 132 persons will not obtain the desired information.
17. Battle of Bunker Hill, the real *Birth of a Nation*, 1775.
18. William Howard Taft, who never imagined he would one day be the second greatest living ex-President, was nominated for President by National Republican Convention, 1908.
19. Northmen are beaten by King Arnulf at Louvain, 891.

*Read about Kadija, his daughter, in the last issue, page 17.

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20. High school orators declare positively that never again will their city's land be tread upon by warring army, Louvain, 891.
21. Tobacco, a well known weed which now furnishes the chief means of support for some periodicals, first raised in Virginia, 1615.
22 Martin Luther translates the Bible, in which is recorded the exhortation to "live peaceably with all men," (Rom. 12:18) into German, 1534.
23. Cato, who was by profession a writer on agriculture and history in 155 B. C., ALSO departs from his own profession, and is nicknamed the Censor.
24. It is now 16 days since Graduation, 1915. During these days expressions resembling the second line of "We Are Happy" have been heard 1,731,286 times.
25. The Seven Wise Men of Greece live, 590 B. C. On the ground that Massachusetts had not been settled at that time, Harvard students object to the appellation, A. D. 1636-1915.
26. Caribsylmethyl breaks the world's record for the mile race in the Pythian Games at Delphi, B. C. 586.
27. Caribsylmethyl, by this time an athlete of wide renown, is admitted to the Eternal Literary Conclave, Sita Lotta Julep, B. C. 586.
28. Billy Sunday despatches several trainloads of sinful mortals to warmer regions, as usual. The earth continues to revolve.
29. The famous Pure Food Bill, by means of which discriminating Bostonians should be able to detect plaster of paris in bread, passed by the House and Senate, 1906.
30. John D. Rockefeller gives $10,000,000 "to promote higher education in the United States," 1905. Of this amount it is estimated that ten million dollars went to the Rockefeller Institute.
31. Announcement—Professor Warren K. Lewis' course in "Theological Chemistry" begins. (See Bulletin of Summer Courses—1915.)

"May I come nearer you?"

"No; I'm afraid if you do you'll—"

"No, honestly I won't."

"What's the use then?"—Lampoon.

'18 (*writing home*)—Dear Dad, send me $500. Money makes the mare go.

Father (*by return mail*)—Yours received. Enclosed $50. That ought be be enough for a jackass.—Tiger.

ENGLISH

State the date of the fall of Constantinople, and include in your answer four reasons why you attend the Institute, also a one-paragraph comparison between the styles of Shakespeare and Huxley. You are requested to give only the information asked for.

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Before Junior Week

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FORTUNATE ACCIDENTS AT THE TEAS.

THE FASTEST THING DURING JUNIOR WEEK.

AT THE PROM

CHAPERONS WERE KEPT GUESSING DURING JUNIOR WEEK.

THE SHOW — AS IT APPEARED TO HIM

During Junior Week

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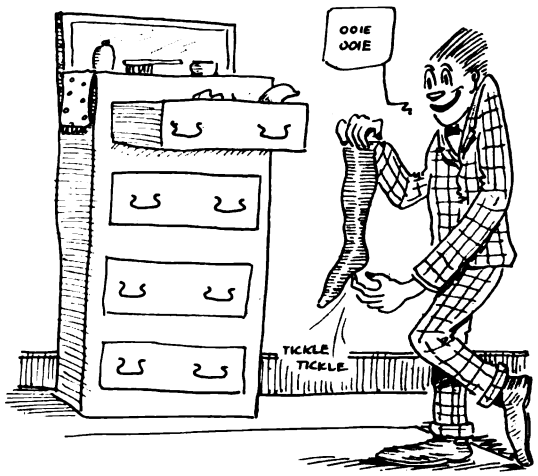
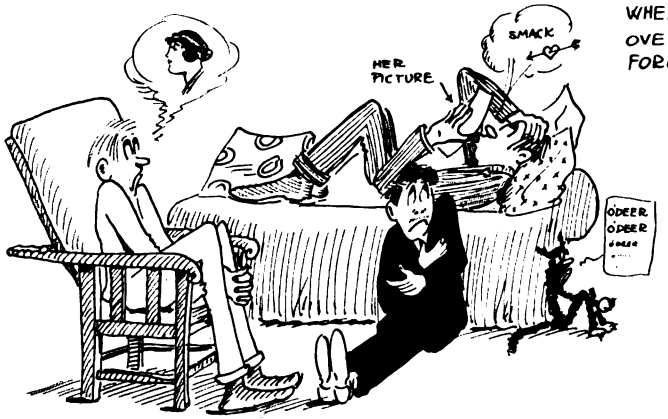
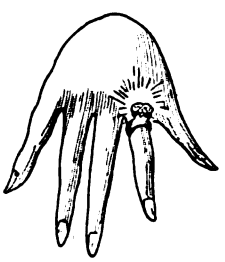
HE TOOK IN ALL JUNIOR WEEK SO IT'S 10¢ MEALS FOR A WHILE



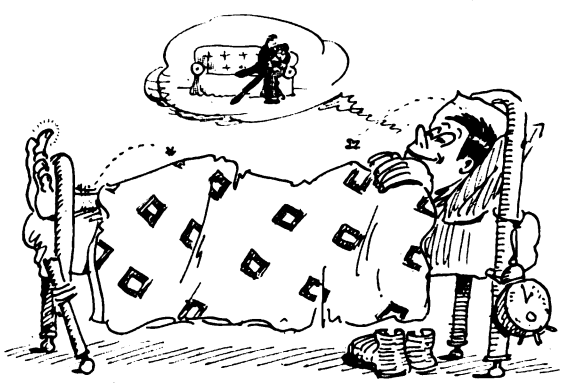
WHEN THE HOUSE PARTY WAS OVER - SOME GIRL WAS FORGETFUL



WHEN THE GIRLS LEFT



HER HAND



NOW FOR A WEEK'S SLEEP.

BACK TO HELL AGAIN.

After Junior Week

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A Few Show Posters Which Were Not Accepted

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THERMODYNAMICS

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AN EXAM WE WOULD LIKE TO TAKE

1. What is water when it is frozen? Be brief.
2. Why does snow slide off the roof?
3. Give the name of a city in Pennsylvania?
4. Do you like German? Really? (Catch question.)
5. Name a member of Congress?
6. Translate "Je ne sais pas."
7. Who wrote Hamlet? (First name also.)
8. Who is your favorite poet?

—Jack O'Lantern.

PEOPLE WE DON'T CARE TO ROOM WITH

The inventive genius who is always working on a flying machine or an apparatus to shut off the alarm clock.

The cold shower fiend.

The guy who is learning to play the piccolo.

The fellow who is a "bear" at making a Welsh rarebit.

The one who had an uncle travelling in Germany.

The Munchausen who tells of the "good old days" when he was a freshman.—Jack O' Lantern.

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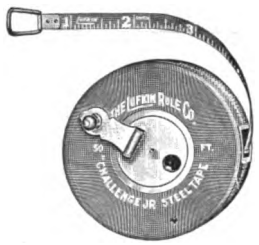

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A passenger train of 8 cars running 40 miles an hour is approaching a freight train of 35 cars running 25 miles an hour in the opposite direction. How far apart will the trains be when they meet?

Ein—"Got a job in a Grocery store."

Zwei—"What doin'?"

Ein—"Teas'n coffee."—Siren.

AT PALM BEACH

"How about a little tango tea, Geraldine?"

"If you grow one I'll never speak to you again. So there!"—Jester.

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THEORETICAL CHEMISTRY I

The vapor-tension of chlorine (Cl) is 6.62 atm. at 20°. If the freezing-point of .1 N. acetic acid is -.3° C., and 1800 students attend the Institute, tabulate values for the ratio between B. & M. passenger rates and the per cent of gold in sea water. Results obtained need not come within 300-400% of the correct answer.

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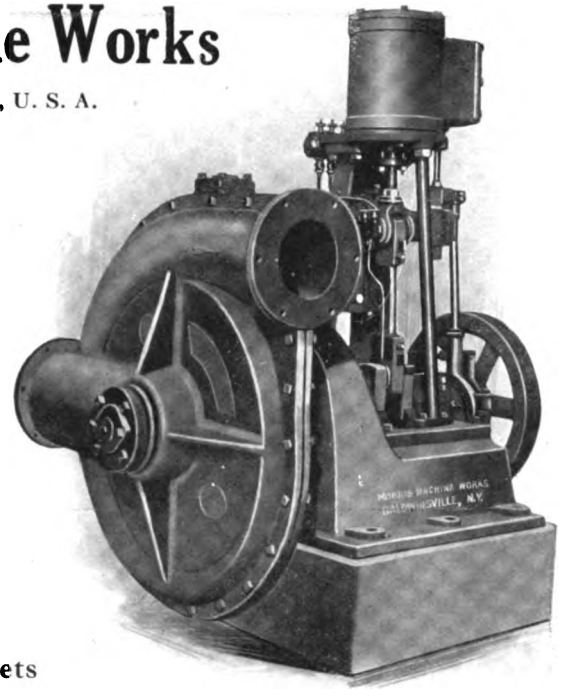

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MATHEMATICS

Derive the formula for the volume of a sphere of influence, using as *r* the radius of the family circle. By means of the above formula find the fourth corner of Copley Square, or any corner of Fort Hill Square.

INHERITED

"What I can't understand about Billy Wiggles is why, with such a splendid, manly man for a father, Billy should be so effeminate," said Dubbleigh.

"Why, it's simple enough," said Slathers. "His mother was a woman."
—Judge.

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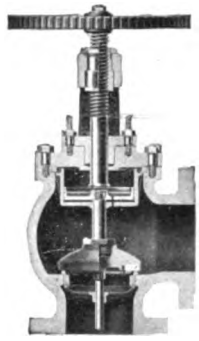

Fig. 293
Sectional View of Automatic Stop and Check Valve, Angle Pattern

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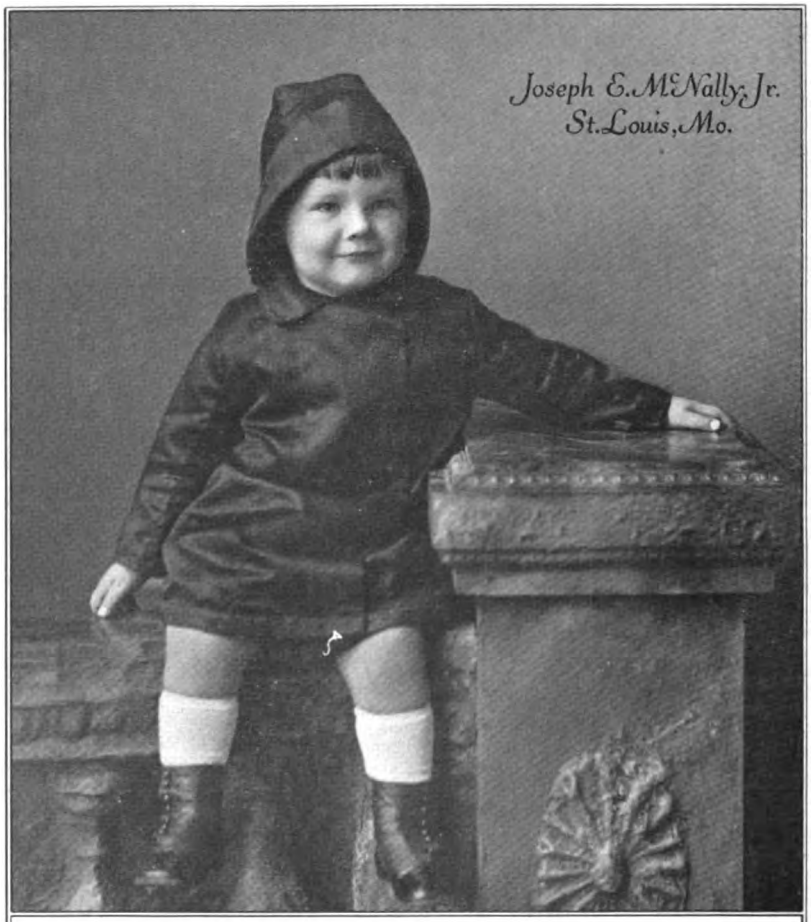

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Copyright, 1915, by The Technology Monthly

Entered as second-class matter at the post office, at Boston, Mass. Published monthly during the college year by the students of the Massachusetts Institute of Technology. Publication office, Technology Union Building, 42 Trinity Place, Boston. Harvard Editorial Office, 218 Pierce Building, Cambridge, Mass.
Mail Address: Technology Monthly, M. I. T., Boston, Mass.
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Subscription rate, $1.50 per year; 25c. per copy. Advertising rates upon application

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THE TECHNOLOGY MONTHLY
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VOL. II BOSTON, MASS., NOVEMBER, 1915 NO. 4

THREE YEARS WITH THE UNITED STATES COAST AND GEODETIC SURVEY

By PHILIP STONE DONNELL, M. E. E., Harvard

Editor's Note. Mr. Donnell has had several years of experience as aid and assistant of the United States Coast and Geodetic Survey, most of his work being done in the Philippine Islands and in Alaska.

This article has been approved for publication by the United States Government.

AS the steamers pass in and out of our harbors or to and fro along the coasts, little does the average passenger realize the enormous amount of work which has been done to make safe the navigation of the waters through which he is passing. He does not know that day after day for many days men have observed hundreds of angles between the surrounding hills, that men have for days trod the shores and the adjacent country, making a minutely detailed map of the outline of the shore itself and the contours of the surrounding hills, and that then, after that, men have for weeks crossed and recrossed the surface of the water, finding the exact distance to the bottom, every few feet in all directions. And besides these three main problems are all the smaller details, such as the automatic recording of the tidal data, without which the soundings in shallow water would be almost valueless, and the determination of the exact magnetic declinations so that the vessels may not go astray as they approach the coast during fog and storms.

It is the purpose of this article to introduce the reader to some of the details of the work in the main divisions of this great Survey and to bring before him, if possible, a glimpse of the magnitude and importance of the work, with perhaps a touch of reality, as I experienced it during my first three years in the service.

As early as 1807 it was realized by our government that a comprehensive survey and mapping of what was then the coast line of the United States was necessary, and on February tenth of that year, Congress authorized Such a survey. But it was necessary to obtain all instruments, and the men to handle them, from Europe, and this, coupled with the coming of the War of 1812, made it impossible to obtain any results toward the organization of the Survey under the Treasury De-

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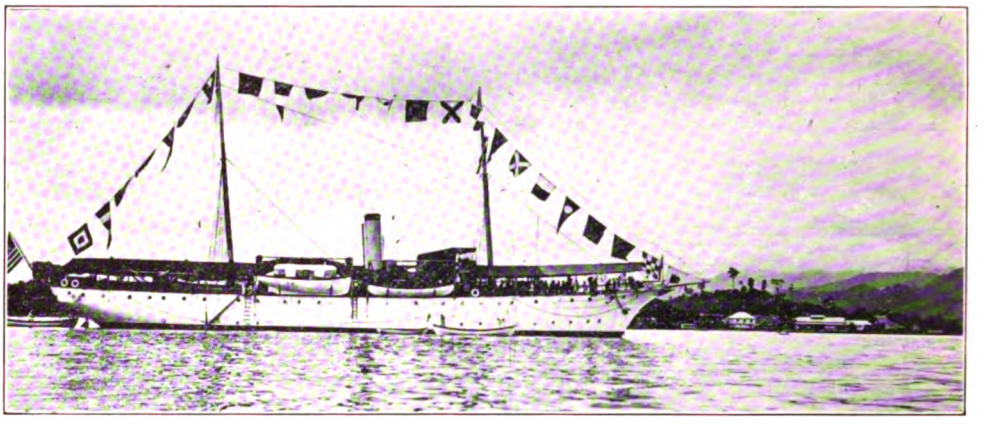

THE "PATHFINDER"

partment, until 1816. In that year the original plans made in 1807 by F. H. Hassler, a Swiss scientist, were put into effect. Work had hardly begun when Congress placed the entire organization in the hands of the Navy Officers, April 14, 1818. Things went on very unsatisfactorily until by an act of July 10, 1832, it again became a civilian service. Two years later President Jackson placed it again under the Navy, and again it was not a success. From 1836 to 1903 it was under the Treasury Department, when it was transferred to the Department of Commerce and Labor. Now, since the division of the latter into two Departments, it has become a part of the Department of Commerce.

From that small beginning, with imported instruments and men, the United States Coast and Geodetic Survey, so called since the Sundry Civil bill of 1878, has grown to be one of the great scientific bureaus of the world, and the instruments and methods it has developed are used by several nations as the last word in accuracy and refinement. As good examples of such instruments may be mentioned the "precise level," to be spoken of again, and the tide predicting machine. The latter is a marvelous mechanism, far superior to anything else of the kind in existeience. It predicts the tides with a very high degree of accuracy for three years, in advance for all the important ports in the world, merely by turning a crank after the known data of the previous years has been set on its dials. And in performing this remarkable feat it is capable of taking into account 37 tidal influencing components, both in time and height, and does an amount of work which could not be accomplished by the direct computation of 100 computers. The first time I examined the machine in 1910 it was working on the tides for Singapore for 1913, and it so happened that during that year I rose and fell on those same tides.

The three main divisions of the Survey's work are Triangulation, Topography, and Hydrography, and under perfect conditions in a well regulated survey this is the order in which the work is carried on. So let us consider that we are at work under such conditions, and begin with the triangulation on an independent section, that is, one not a continuation of an old scheme. The first thing is to establish a station and determine its latitude and longitude by a series of observations.

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LATITUDE

There is but one standard method of determining latitude. This is the so-called Horrebow-Talcott Method in which there is substituted for the measure of the absolute zenith distance of a star the measurement of the small difference of zenith distances of two stars culminating at nearly the same time on opposite sides of the zenith. This, being a differential measurement, gives a far greater degree of accuracy than the usual methods found in works on astronomy. It can be seen that by this method, instead of trying to correct for a single large refraction, as when observing on Polaris, there is used the very small difference in small refractions with almost equal altitudes.

LONGITUDE

Three methods are in use, of varying degrees of importance.

1st. The Telegraphic Method, which is by far the most accurate, and which is always adopted where it is possible to get telegraphic communication. Wireless telegraph, in remote regions not served by the ordinary wire system, although giving sufficient accuracy, has not yet been adopted for surveying purposes in this country because of its being more expensive. The telegraphic method was inaugurated by the Coast and Geodetic Survey in 1846, two years after the first telegraphic message was sent. During the intervening years it has been brought to its present high state of perfection by this department.

2nd. The Chronometric Method. To determine longitude by the chronometer means that there must be some method of carrying the chronometer back and forth several times between two stations, one of whose longitudes is known, and of course the farther apart the stations are, the more inaccurate and expensive the method becomes. It has been used a great deal in establishing stations along the coast of Alaska, where there was direct ship transportation.

3rd. The Lunar Methods. These are the least accurate and involve a serious amount of computation, and, as a result are only used where neither of the other methods is practical or possible. An excellent illustration of the occasional very practical value of the lunar methods was the determination of the longitudes where the 141st meridian crosses the Yukon and Porcupine Rivers, in the recent redetermination of the boundary line between Canada and Alaska. Here there was no possibility of a telegraph and the nearest station was a thousand miles down river at the mouth of the Yukon. The determinations by this method all lay within a range of 1.1 seconds of time. An initial longitude had been telegraphically determined some four hundred miles south and when the stations were connected the telegraphic determination lay within the range of the lunar determinations.

AZIMUTH

Azimuth, the direction of true north, is determined from observation on Polaris.

BASE MEASUREMENT

The above determinations are usually made by a party under special instructions. The first work of the party doing the work of the general surveys is to determine a length or base, as it is called, upon which to start the triangulation scheme. The old idea was that the base must be very long, six or seven miles, in order to be sufficiently accurate, but at the present time three to five miles is considered sufficient. The most striking change, however, in the

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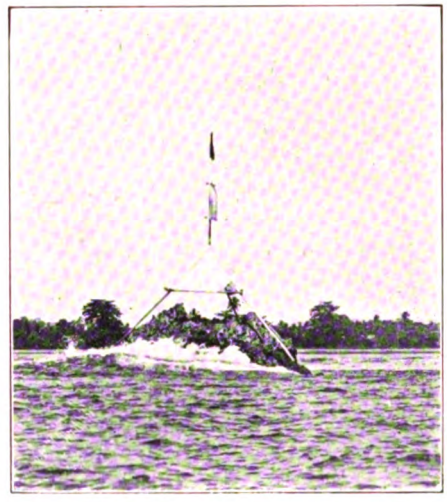
advance of the art is in the apparatus employed. The old standby was the slow and tedious bar method by the use of which it took weeks to perform an operation which now requires an equal number of days, when using the simple tape made from the nickel and steel alloy known as "invar." A fifty-meter tape is used supported at the ends and once in the middle and during the measurement held at a constant tension of



TOPOGRAPHIC CONTROL SIGNAL

15 kilograms. The temperature correction is then made and also the correction for difference in elevation between the two ends of each section. Each section of all primary bases is measured with two different tapes and the results obtained are so accurate that a remeasurement would give a result agreeing with the original one within one part in two or three million. This would mean that were we to measure the 14,620 meters between Park Street, Boston, and Harvard Square, Cambridge, and had a discrepancy of one part in 1,462,000, measurements of the entire distance would differ by but one centimeter.

In the Philippine Islands, owing to the mountainous and densely wooded character of so much of the country, a large part of the bases are measured on the sand beaches. At times straight stretches of several miles are obtained while usually there are one or more breaks where the angle must be very accurately measured. It is undoubtedly fortunate for those who must make the measurement, that they can be done along the shore, for back in the level cleared valleys in the dry season, when the work must be done, the heat is terrific, not only from above but from below, for the ground seems to be a veritable stove lid. I shall long remember a measurement made in just such a place. It extended 4,800 meters straight back to the hills through a sea of charred cogon grass stubble, for there had just been what is called in this country a prairie fire, and where the fire had missed, the grass still stood six feet high. Through it, of course, a channel had to be cut and it is certain that no breeze ever lowered the temperature below 120 degrees Fahrenheit.

Having obtained a length for one side of the original triangle the next thing is to establish stations on intervisible mountain tops whereby a series of triangles may be formed and the known length carried forward. It is in this work, especially in the Philippines and mountains of Alaska, that one finds not only the most spectacular and interesting work but also the hardest and most trying. The mountains of the Philippines have a maximum elevation of ten thousand feet (although stations are rarely placed at elevations over five thousand feet in the coast work) and are in general covered with the dense tropical growth of timber and vines which seem to embrace all the types of thorns and entanglements that exist. In

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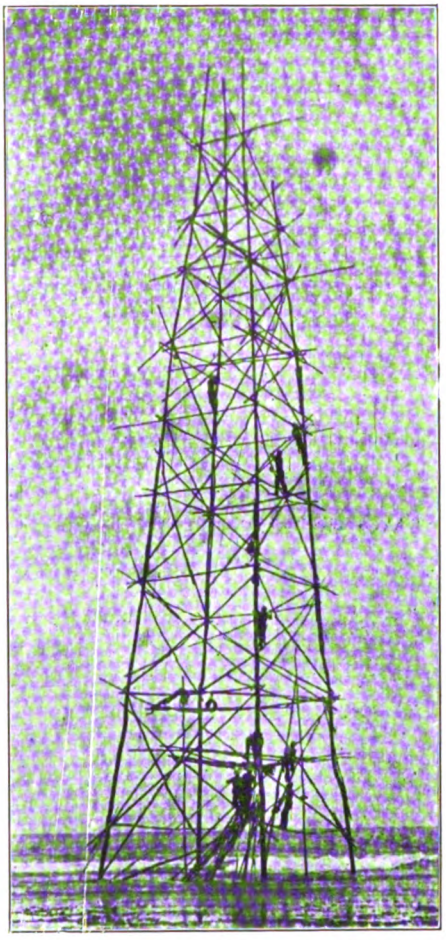
many places progress is very slow because of having to cut one's own way—I have spent six hours traveling two miles. Finally, when the crest of the ridge is reached, the search is begun for the exact location, for perhaps from a station thirty miles away, one point only on this mountain is visible and that one not the highest point. This means climbing the trees from which you make a guess that you can see out, and when the trees are one hundred and fifty or more feet high, and their tops a dense mass of foliage, it is extremely difficult to tell beforehand about what can be seen on reaching their upper extremities.

The usual method of climbing these trees is to nail on cleats ahead of one, about three feet apart; and when, after some hours of work the top is gained, it is disappointing to discover that not fifty feet away is the top of another giant just hiding everything in the particular direction in which you wish to see. Sometimes nails run low and one cannot put up cleats but must climb with single nails. The sailors, of course, are supposed to, and do perform most of this, but sometimes their nerve and strength fail them and the officer must take a hand in order to accomplish the desired results. It was on such an occasion that I was approaching the lower branch of a huge tree some ninety feet from the ground, driving the nails ahead of me, when suddenly the pounding aroused an enormous nest of ants in a bunch of orchids which had collected the usual amount of dead leaves, etc. Out they poured in thousands and literally covered the tree and me, and at last, just as I was about to drive the last nail, with an ant in one eye, another walked into the other eye and I had to give up and climb down that ninety foot ladder of single nails with both eyes tightly shut in order to prevent, as much as possible, the movements of the entrapped pests.



TOWER MADE OF JUNGLE MATERIAL

However, one gets accustomed to the work, his judgment continually improves so that the finding of the right tree becomes a much simpler task. On one of the last trips I made, some miles inland, onto a 3,000 foot mountain which was of nearly uniform height for half a mile, I climbed at the first attempt the one tree that protruded eight feet above its neighbors and which I had seen and determined upon from a point some twenty miles away on the other side of the peninsula.

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Before these trips are started from the coast an estimate is made of the number of days that will be required and food for the whole party for that time, along with the necessary instruments, is packed in by the sailors and native laborers who may be hired on the spot. After the approximate position for the signal has been determined, a camping place is chosen as near the top of the mountain as good water can be found, and the work starts. Depending upon the country and conditions we either hang up our hammocks or build pole beds roofed with palm leaves or tarpaulin. The sailors arrange their hammocks around the edges of the opening which they have cleared between the trees, and this place we learn to call home, and however crude things may be in it one hails the sight of it with delight after a long, but hot day's work at the signal, and the glorious evenings, always cool, easily compensated for the day's hard work. It is the memory of some of those jungle evenings that gives one a longing to get back to that life in the wild, untamed realms of nature. One picture stands out very clearly and I have found a description of it written at the time in my diary which will, perhaps, give a glimpse of the life. In general it runs as follows:

"Having determined on the location for our camp near the topmost spring on the mountain, the dense underbrush had been cleared away and one large tree had been cut, which left an empty space some fifty feet in diameter and one hundred feet high nearly covered with a canopy of leaves which seemed to rest on the tall columns of the tree trunks. To one side was built the shelter roofed with the palm leaves and in the centre was the fire place where the cooking was done. . . . (At night) There we sat on a fallen tree beside the flickering camp-fire which shot its uncertain rays out over the heads of the dark skinned laborers and softly lighted up the great brown trunks of the primeval giants, festoned in ghostly fashion with the

A CAMP IN THE MOUNTAINS

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beautiful vines of the tropics, while all around from the dense blackness of the jungle beyond them came the shrill singing of myriads of insects. And, far, far above through a tiny opening in the black dome which the light of the fire could not reach, twinkled two little stars, the only thing to tell us that the world without was still real."

To be sure such is life in the jungle at its best, but there is so much of the best that the worst only adds a greater interest.

Having once determined the location of the signal, one must decide whether it is to be a tower in order to enable one to see out over the trees, or a station on the ground with lines of sight cleared in the directions of the signals to be seen from ten to fifty miles away. If the mountain top is very sharp it is much more economical to clear away the trees, but if it is broad and flat and clearing the lines would necessitate cutting fifty or more trees up to six and eight feet in diameter, the only thing to do is to build a tower of the necessary height to show above them. We have built towers in the jungle out of nothing but jungle material, using largely rattan for seizing the joints, up to heights of nearly 150 feet. Then, too, one often encounters instances where, on an otherwise easily cleared peak, towers up to one hundred feet in height must be erected to see over intervening mountains of almost identical elevation. These towers being erected with the signal tripod on top, covered with white or black cloth, depending upon the background, the system is ready for the observations. Each angle in the main scheme is observed from 12 to 48 times, depending upon the accuracy desired and the class of theodolite used. Besides these main scheme observations, angles are also read tying in all subsidiary or topographic control signals and any prominent objects and mountain peaks. Vertical angles are also read on main scheme stations and mountain peaks.

TOPOGRAPHY

When the topographic control signals, placed every four miles or less along the coast, are located through at least two triangles, the country is ready for the topographer, who comes in for his share of the excitement, if he is working on an exposed coast. As it fell to my lot to run a traverse for 350 miles (as the shore runs) along the east coast of Mindanao, a shore exposed continuously to the swell of the open Pacific, I feel that I have known some of this excitement.

The purpose of the topographer is three-fold:

1st. To obtain an accurate outline of the shore at high water, and as far as possible the extent of the reefs at low water.

2nd. To produce a contour map of the mountains and hills visible from the sea, putting in 100-foot contours. Locations of prominent peaks and shoulders in this work are obtained by intersections and contours are sketched by the eye. Of course this is the method only along the unimportant coasts—not around the harbors, where the contouring is done by more accurate methods.

3rd. Signals of white cloth or white washed rocks must be built and located approximately every 400 meters on ordinary open coast, for use in the location of the soundings made by the hydrographers.

HYDROGRAPHY

The character of this varies a great deal with the character and importance of the surveyed area. Where a rocky, unfrequented shore drops off steeply

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into deep water, soundings may be taken from a launch no oftener than every 200 meters, whereas in a shallow bay which may serve as a harbor the work is done from row boats with soundings taken every few feet. Furthermore, today, in important channels and harbors one further refinement is added. This is the wire drag work, wherein a long wire is drawn horizontally through the water at a fixed distance below the surface, which depends upon the known least water in the channel and the depth desired. The wire is held at the fixed distance below mean sea level by means of buoys with adjustable-length uprights, weights and counterbalancing toggles. The length of upright between the buoys and the wire is changed as the tide rises and falls, the exact amount being determined from the predicted tides which have been previously mentioned. It has been shown that almost any projection, either rock or sand, rising six inches above the depth at which the wire is set, will serve to catch it and stop the towing launches, or at least, if it is sand, retard them. In open waters and wide channels, as, for example, those of Penobscot Bay on the coast of Maine, drags up to two miles in length have been successfully operated, drawn by four launches. However, with this length the resistance is so great that the tide is relied on for propulsion, the allowable strain on the wire being only sufficient for a speed which affords steerage way. Before the final charts for the entrance to the Panama Canal were made the entire area was dragged to disclose any obstruction which might have been missed by the sounding.

All the deep sea sounding is done from the vessel by the use of a steam driven sounding machine, using either the up and down cast by stopping the ship each time, or the automatic depth registering devices which are used with the vessel moving five to eight knots an hour. One of the greatest ocean depths on the globe is some forty miles off the east coast of Mindanao, where it is about 5,000 fathoms. Fifteen miles off the coast we obtained 2,500 fathoms.

Beside these three main divisions of the general survey there are the Precise Leveling and Magnetic Divisions. The Coast and Geodetic Survey has developed a precise level which has become the standard in several countries. It differs from the common level, in that, at the same time the rod is being read with one eye the exact position of the bubble is being read with the other. This makes it not only the most precise level in existence but also makes it capable of very rapid manipulation. During the 15 years that this level has been in use in the United States Coast and Geodetic Survey some notable records have been made both in speed and accuracy. In October, 1914, on a line of levels between Butte, Montana, and Pasco, Washington, 148.3 miles of levels, run in a backward and forward direction were completed. The maximum run for any one day was 20.3 miles, of single line, made in 7 hours on October 12, 1914. The accuracy attained is best shown by the closures of the large circuits. The leveling done in recent years by the Coast and Geodetic Survey has an average closing error less than 0.2 millimeter per kilometer.

MAGNETIC SURVEY

In the survey the declination, dip, and intensity of the earth's field are determined not only along the coast but at sea and at hundreds of points within the continent.

We have thus attained a bird's-eye

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TOPOGRAPHIC PARTY

view of the field of operations of this, one of the very important of the smaller bureaus of the Government. And it may be added that the actual survey and charting work is not all that is being accomplished, for it is largely through the results of the bureau's great triangulation schemes that a new and more accurate determination of the earth's figure has been computed.

It might be thought that, as the original survey of the entire coast of the United States has been completed, i. e., the original purpose of the bureau fulfilled, the work should be falling off, but on the contrary it is ever becoming of more vital moment. As long as harbors gain in importance, requiring more and more accurate surveys; as long as the ships increase in draft; and as long as our coast line and the depth of adjacent waters change, as they do now in many places, there will be a need of such a Service. But aside from that, there is work to keep the fleet busy for many years to come, making the original survey of Alaska and of our newly-acquired island possessions.

What is needed now is an added appropriation to replace some of the old vessels which, although unseaworthy, cannot be put out of commission because of the great pressure of the work that must be done. With the ships that are now in Alaska, it is impossible to keep pace with the demands made by the rapid opening up of the country, and, as Secretary Redfield of the Department of Commerce has said, it is time that enough money was appropriated for the Survey to terminate the custom of giving to the new reefs which are being discovered from time to time, the names of the vessels that are lost upon them in their discovery. To equip the entire Alaskan contingent for perfectly safe and efficient work would require no more than the amount lost when a single large vessel goes down with its cargo on an uncharted rock.

The Coast and Geodetic Survey is a Service into which a young man just out of College can enter and in two or three years receive a wonderful store of experience in the use of his own initiative and in making quick decisions in time of difficulty and danger, and in the handling of men, for from the first one is placed a great deal upon his own resources.

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Were the casual observer to go through the experiences usually encountered by a Coast Survey Officer in his daily work in the outlying districts of the Philippines, where even yet there are stretches of coast line put on the charts with dotted lines and marked unexplored, he would undoubtedly pass the opinion that it was a dangerous service but it is almost never that anyone is lost. The writer has been through four East Indian typhoons in five weeks, but each time the good ship "Pathfinder" rode it through. There were thirteen steamers anchored in Cebu Harbor when the famous storm of 1912 broke upon us, and twelve hours later, when morning dawned and the worst was over, it was seen that but four of them had stood the test. The rest were on the bottom or had been washed up on the reef. Another storm was ridden out in the open sea, as we were unable to make a port, while 200 miles to the westward of us another of our vessels went aground, but no one was even injured.

It is through these experiences, that one gets in these wonderful storms on the great ocean, spending the weeks on the mountain tops, where one may look down on the clouds, meeting the people of wild and savage tribes, and above all the feeling that you are not a mere cog in the whole, but a human being working to the utmost limit of your innate ability to find the means of accomplishing the end for which you are striving, —it is through all these things that one comes to have a deeper and clearer conception of lift as a reality, and a very vivid picture of the first years with Uncle Sam, helping him to make safe for the mariner, the paths of the sea.

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THE ENGINEER IN PUBLIC SERVICE

THE FUTILITY OF OVERREGULATION

By ALEX C. HUMPHREY, President Stevens Institute of Technology

Editor's Note. Prof. Alex. C. Humphreys, the President of Stevens Institute of Technology, in this article presents several of the consequences of the overregulation of industries. While we do not agree with Prof. Humphreys in everything that he writes, he has portrayed a great menace, and as a remedy has opened a field for graduates of Technology and the Harvard Engineering School.

APPARENTLY the great mass of the people are either misinformed or indifferent to the results which have come from the schemes of regulation which have been inaugurated through their hastily expressed disapproval of isolated cases of abuse of power or opportunity.

This being a government by the people, the people appear to think that it is incumbent upon them always to be active as lawmakers; and this incessant activity naturally favors quantity rather than quality. It would seem as if each time that there appeared to be a need for the application of the restraining force of law, a new law must be passed rather than there should be made a stronger and more intelligent effort to enforce the laws already on the statute books. Our country has suffered much through the activities of those who with honest intentions were signally unqualified to effect constructive reforms, not to speak of the activities of others not qualified even by honest intentions. The country is being victimized through the fanaticism of idealists, the cocksureness of book-economists, and the skillful scheming of self-seeking politicians.

It would be well if in at least one of our states fundamental laws might be diligently and consistently enforced so that the people would be educated by the results, good or bad. This would reduce the activities of the yellow journals and practically put out of business a certain type of politicians and lawyers.

In order that it may not be thought that I am exaggerating this evil of excessive and faulty lawmaking for the correction of evils only superficially studied, let me quote a lawyer, legislator, and administrator of international reputation, Senator Elihu Root. In an address delivered last year he gave the following facts, and expressed his views thereon, as follows:

"We make too many laws. Our national and state legislatures passed 62,014 statutes during the five years from 1909 to 1913, inclusive. During the same five years 65,379 decisions of the national and state courts of *last resort* were reported in 630 volumes, Of these statutes 2013 were passed by the national congress; and of these decisions 1061 were rendered by the Supreme Court of the United States.

"Many of these statutes are drawn inartistically, carelessly, ignorantly. Their terms are so uncertain, vague, doubtful, that they breed litigation inevitably."

We have all had experience with the kind of lawmaking which Senator

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Root so unsparingly condemns. The law under which our federal income tax is levied is a flagrant case. Here the authorities charged with the enforcement of the law have been obliged so frequently to change their rulings that our legal advisers have had to write and rewrite the opinions intended for our guidance.

As a result of experiments in law-making we are now an overregulated people. No longer are we in accord with the teachings of Thomas Jefferson, who said:

"Agriculture, manufactures, commerce, and navigation, the four pillars of our prosperity, are most thriving when left free to individual enterprise."

It may be said that these are not the days of Jefferson. True, but it is the same human nature we are dealing with; if no better, certainly no worse.

No doubt conditions had developed in connection with our industries and our commercial activities which required some measure of regulation under the law. These changes did not call for hasty and radical legislation but for legislation based upon the widest possible experience, judicial consideration, and coöperation of all interest involved.

The Interstate Commission, of its own motion, has made twenty-six inquiries, including investigations of the express companies, the telephone and telegraph companies, the financial history of railroads, etc. In addition, Congress placed upon the Commission nine most important investigations, including those of the New Haven Railroad and the United States Steel Corporation. This was enough, we would think, to satisfy the ambitions even of men hungry for power, but in the report referred to we find the Commission asking for more work and more power. Again bear in mind Thomas Jefferson's warning. An examination of the records of the State Commissions would disclose the same very human tendency to assume more and more power and so to deprive owners of the management of their own properties.

It is to be particularly noted that the hearings or trials conducted by these commissions all too frequently indicate partisanship and bias on the part of the presiding official. The Commissioner who conducts the hearing frequently examines the witnesses himself—in a way to cloud and confuse rather than to clarify the record. It is eminently proper that the official presiding at investigations should cross-examine the witnesses, but it should be done in a way to draw out the truth, the whole truth, and nothing but the truth. A stupid or timid witness should be helped to develop the truth and not cross-examined after the manner of a lawyer holding a brief for a client. The fact is, these officials too often do hold a brief against the corporations which are brought before them presumably for a fair hearing. I presume there are many men who know by experience that I am not exaggerating. Many could endorse all and more than I now charge if they did not fear that they would thus weaken their influence before the Commissions.

I am firm in the belief that we who are directly concerned are unfaithful to our trusts when we fail to protest against the injustices which are practiced under the cloak of investigating. A scandalous and humiliating example we have recently had an opportunity to study—the investigation conducted by the Chairman of the Federal Industrial Commission. In at least two cities, before opening his hearings,

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he made public addresses which showed that his opinions were radical in the extreme and were already firmly fixed. In answer to criticism of his course in this regard he stated that he was not of a judicial turn of mind and he proposed to conduct his investigation on the basis of the opinion he already held. Think of such a man being appointed to conduct a nation-wide investigation, and think of the humiliation of those who were willing to serve on the commission under such an unworthy leadership and to accept their share of the responsibility for his demagogy. Such a man as this Chairman, and there are many in this country today, is incapable of understanding that the maximum of progress, both as to speed and permanency, is secured only by the retention of all elements which have met the test of years. True progress means conservation of the good and the elimination of the faulty only. Our present-day reformers are willing to pronounce all as bad on the score of age alone.

It has been well said that the regulation of our railroads and other public service corporations has now resulted in their strangulation. Even to the Commissions and others responsible for these conditions it should now be evident that there is one element in this problem which cannot be regulated and controlled by foolish lawmaking and zealous officials—namely, the investor. Finally it must dawn upon those who are now so much more active and uncompromising in managing other peoples' affairs than they are in managing their own, that the investors are not a select body of bloated capitalists, but they are in large part the working men, dependent women, and minors under guardianship, all the people who are now saving or who have been saved for. The failure to recognize this truth was evident in connection with the committee work on the Income Tax law and particularly with regard to the responsibility of trusteeship carried by our great life insurance companies. And it is only now just coming to be understood by these people whose investments have been in public utilities that they are injured by this overregulation, which has developed into tyranny and persecution. Many of these people have been, yes, and yet are, complacent with respect to this so-called regulation because they do not appreciate that they are the owners of the properties under attack.

The case would not be so bad if the Commissions and the government were willing to submit to the decisions of the courts when they are overruled. But the struggle is continued to the end; and if one attack fails another is planned.

This abuse of power has now come to the point where the officers of the railroads and other public utilities are forced to devote their time and energy, yes, and money, to the defense of their properties rather than to their administration and betterment.

When we reflect on the favorable showing made by our railroads as compared with the railroads of Europe, as to capitalization per mile, charges for freight and passenger carriage, facilities and accommodation afforded to shippers and passengers, and rates of wages paid to employes, we find it hard to hold back our sympathies from the owners and operators of these properties. In the past this paternalistic development of overregulation has been confined to the public utilities, and so there has been less public concern, for

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strangely enough the public failed to appreciate that the prosperity of the country depended in the largest measure upon the prosperity of the public utilities, especially the transportation corporations.

It is not a coincidence that the railroads and the country as a whole are suffering from bad times. These results are necessarily linked together.

The farmer through cheap transportation lifts his mortgages and is enabled to give advantages to his children not before obtainable—and after a while damns the railroads for not giving him cheaper rates. High finance has to take the blame, but it was only through high finance that this country has developed—and "high finance" by no means is always synonymous with fraudulent finance.

I venture to assert, in connection with the reckless charges made as to the general inclusion of "water" in our railroad capitalizations, that if the great railroad systems of the country were appraised fairly, the present value of the physical assets would be found to exceed the face value of their bonds and stocks. But the improvement and extension of these properties in the service of the public cannot be continued under the present repressive measures. Under the circumstances it is somewhat remarkable that railroad men can find humor in the present situation. But such is sometimes the fact.

One railroad official proposes that the farmer should be regulated under commission authority for the benefit of the hired man. He offers many suggestions as to rules, from which I quote a few:

"Every farmer shall hire one more hired man than his work requires.

"The only permissible exception to the foregoing section shall be periods of stress resulting from earthquake, Halley's comet, or European invasion.

"All wagons and all poles and double trees shall be provided with couplers, coupling by impact, so that the hired man need not go between the wheels of the wagon and the heels of the horses.

"All field engines and machinery shall be fenced in, all belting shall be encased in metal housings, and all grindstones, churns, hay-cutters, bull's horns, and other moving parts shall be strongly encased in sheaths for the protection of the hired man.

"If a calf is delayed in arriving or is born dead, the farmer shall instantly provide another cow whose calf shall be born that day.

"To enforce this act a Commission of of five persons shall be selected by the Governor with a view to placating as many shades of political opinion as possible. No Commissioner shall, however, be deemed disqualified by lack of previous political or other experience."

As I have said, in the past this governmental regulation or control of private enterprise has been confined to the public utilities. But now we are to experience a much broader application of the system.

We have now in operation the Federal Reserve Bank system. That is capable of working to the advantage of the country at large in spite of its faults. One advantage it has is that its results will be compared with results obtained from a system acknowledged generally as defective, and in the first place designed only to meet an emergency. This Federal Reserve Bank scheme was put into its present form only as the result of persistent protest on the part of those outside the Congress, and in its present form is largely indebted to a plan offered years before and rejected.

Now we are to have a Federal Trade Commission to operate under a law

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which is monstrous in its provisions as affecting the liberties of our citizens. It attempts to establish a claim for impartiality by providing that its membership shall not be confined to one political party. The effect of this provision, however, is to make this commission a political body; for, before a man can be selected for service thereon, his political affiliations must be established. The appointments made just as the last Congress was closing furnished an example of this political feature.

The Interstate Commission has had about 3,000 railroads to regulate, control and manage—call it, what you will. This new commission will have to care for not less than two-thirds of the 300,000 corporations of the United States, not to speak of the partnerships and individuals engaged in interstate commerce.

Considering the confusion and damage wrought by the Interstate Commission through its excess of zeal, lack of experience, and prejudice. I believe within limits its work has been beneficial and could have been far more so. What may we expect from this new, untried commission, working along new lines, without experience, and necessarily having to meet opposition from a liberty-loving people?

We know the evils which come from those "clothed in a little brief authority" —but here we fear the authority may not be brief and certainly must extend to the next general election.

In the meantime let us bear this in mind, those of us who are looking for some opportunity to work out our own salvation, that a majority of 19 men (four of the Interstate Commerce Commission, four of the Federal Reserve Board, and three of the Trade Commission); that is, eleven men, can make or unmake the prosperity of this country of one hundred million people. This is a regulative power which should not be placed in the hands of any one body of men, and especially in the hands of such a small number of men *appointed* to office.

But there are other forms of regulation outside of these Commissions. The Bureaus in Washington have large powers which are constantly being added to. The Sherman Law gives these departments large possibilities for interference and oppression.

You all have a chance to study the Income Tax law,—class legislation. Do you understand it? But do many of you understand or even know of the United States Cotton Futures Act recently passed, sometimes known as the Smith-Lever Act in *"honor"* of Senator Hoke Smith and Congressman A. F. Lever? This act undertakes to control the management, the methods, the routine of practice of a great branch of our business life. It limits the right of private contract in favor of a section or class of the nation. Distinctly it is class legislation. If this is proper regulation for the cotton business, why not for iron and steel, lumber, grain, groceries, etc.?

Not only will the cotton merchants have to contend with the law, but they will have to contend with its interpretations as given by the Department of Agriculture, the Internal Revenue Department, and, finally, the courts. The law is ambiguous in its terms, and so interpretations, whether honest or dishonest, must widely differ. Let me remind you of my quotation from Senator Root. If an interpretation as given by either of the Departments named is later found by the courts to be incorrect or insufficient, or by *subsequent officials*

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of either department, no protection is found for the merchant, as the revised *interpretation is retroactive.* From the time of enactment there were six months left for the interpretations to be made so that the merchants could get acquainted with the requirements in advance of the time to be put into effect; but the departments used all of the six months in their studies and left no time for the poor people most directly concerned to prepare for the new departure.

Is this a "reform" to be proud of? The final result must be to the disadvantage of the cotton grower as well as the cotton broker and merchant; poetic justice.

One of the most apparent reasons for the present business depressions and unrest is the inability of business men and even lawyers to decide what is fair, and what is unfair business practice. And there are the best of reasons for this paralyzing uncertainty. When a man honestly tries to find out what should be his course to meet the law's requirements and fails; and then he applies to his legal counsel and fails; and then applies to the government's representative and fails, he cannot fairly be blamed for not appreciating the benefits offered by the "new freedom."

A large corporation in the West was sued by the United States Government for unfair practices. A member of the jury asked the Judge to tell him what constituted unfair practice. The Judge told the prosecuting attorney to supply the definition. He acknowledged his inability. The Judge then turned the question over to the counsel for the defense, with the same result. Finally the Judge had to acknowledge that he was unable to instruct the jury, and so the jury were left to supply a definition for themselves, which they did. This is certainly a phase of the "new freedom" with a vengeance.

It seems to be forgotten that the fundamental business law was not the creation of lawyers and legislators, but was a gradual development under the guidance of business men.

Let me quote a few passages from a notable address delivered recently at the Lawyers' Club of New York by an eminent member of the New York Bar—Henry D. Estabrook:

"Prior to Lord Mansefield's time the Law Merchant was a law peculiar to itself. It was created by merchants and administered by them, just as our Stock Exchange has its own rules and its own forum for enforcing them. This Law Merchant was based on the customs of merchants in conducting their business, and these customs in turn grew out of their business experience. It was justice as the merchant saw it; and to his thinking of a higher, finer, and more sensitive quality than that known as municipal law; for, as one ancient writer says: 'The credit of merchants is so delicate and tender that it must be cared for as the apple of a man's eye' * * all the earlier commentators on this law were not lawyers, but merchants * * Now these old-time merchants had their 'trade unions,' their 'pools,' their 'gentlemen's agreements,' their combinations in 'restraint of trade'; but all within limitations prescribed by their own customs, which customs from long experience they had found to be just and reasonable. * * I find it hard to define justice except as a moral equilibrium * * Experience evolves its own definitions and, as I have shown, the law is based on experience and not on the categories of logic."

Then the speaker goes on to show how Lord Mansefield, when he took his place on the Bench (in 1756) consorted with the merchants for the purpose of learning their ideals, methods, and business habits. The result was that Mansefield declared the Law Merchant to be

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the Law of England, and this maxim embodied the law of this country up to the time the so-called Sherman Act first came before the U. S. Supreme Court for judicial interpretation. Four of the members voted for interpretation by the light of reason—common law—but five voted that it should be construed literally, and so by a single vote in a court of nine judges, the law of the land was revolutionized, and "regulation" was enthroned.

Now shall we place the burden of blame for these present conditions upon the shoulders of others or shall we acknowledge that we are to blame, ours being a government of the people? Much of the inefficiency and lack of economy in government legislation and administration is due to the fact that we who are active as producers leave public policies too much to the politicians and "reformers," the non-producers. If we allow these people to manage the affairs of the nation, they will do so. That is human nature. I was talking with a friend lately who is engaged in the cotton brokerage business in a large way. He is a man of character. He is deeply concerned over the Cotton Futures Act to which I have referred. *He said that he never has taken any interest in politics for the reason that he finds an outlet for all his mental strength and energy in his business.* Now he recognizes that he has erred and hereafter he is going to interest himself in public affairs and especially in *elections*. Here is the human nature of it, and here is where we can look for relief. But we should do our best to hasten the day and take a less selfish view of the situation.

I am reminded of a story told to me some time ago by a friend. Inspector X of the New York Police, a man noted for his courage, promptness in action, and directness of purpose, was walking down a side street near the Bowery when the friend with him drew his attention to a man from the country, carrying an old-fashioned carpet bag, and apparently at sea in the great city. He was approached by a man of the "bunco steerer" class. The friend drew X's attention to the necessity for helping the poor man from the country,—to save him from the clutches of the confidence man. X declined, and said he could not take care of all the old hayseeds who came to New York, that they had to learn by experience, etc. Suddenly X jumped across the street, grabbed the confidence man, cuffed him, kicked him, and generally wiped up the floor with him. His friend joined him after things had quieted down and asked him what had caused him to change his mind so suddenly and completely about the protection of hayseeds. The Inspector replied with an oath of no mean dimensions, "Why, this man is my brother."

Now what has the engineer to do with regard to the problems I have so imperfectly and inadequately discussed?

With all other citizens, the engineer's duty is to take part in shaping the government, and especially at the primaries —official and otherwise—*and elections.*

But the engineer has a very definite, specific responsibility in this connection. Most of the great problems of government now up for settlement are concerned with the industries. Many of the questions are *engineering* questions. Many others are of a nature such that the engineer's training would help him to solve them. Take for instance the questions before our Interstate and State Public Service Commissions.

Our Public Service Commissioners are generally either lawyers or economists.

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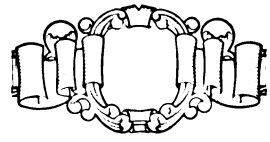
It is bad enough to have too many lawyers in such positions, but the mixture may be much worse.

I hold that our Public Service Commissions should all have as members *at least* one engineer. Not that a man is qualified for that important position because he is an engineer any more than a man is qualified to sit on the Bench because he is a lawyer. But a Judge must be a lawyer, and on these Boards there must be engineers if the questions to be settled are to be settled fairly and competently. An engineer to be competent for this position must have had a wide experience as operator and administrator as well as designer and constructor.

But notwithstanding the fact that many of the questions which our public service commissions are called upon to determine require for their solution the highest engineering training and experience, it is the exception when an engineer is appointed as a commissioner.

Judge Prouty, for many years Chairman of the Interstate Commerce Commission, and now Chairman of the Federal Board to value the railroads, after years of experience has so changed his views that he now believes that the engineer is better qualified by training and judicial-mindedness for a commissionership than is the lawyer.

W. M. Daniels, now a member of the Interstate Commerce Commission, and formerly a member of the New Jersey Public Service Commission, has recently expressed himself also in favor of putting engineers on these Boards rather than employing them only as members of the staff. Mr. Daniels is an economist. So here we have the lawyer and the economist agreeing that they need the help of the engineer as an equal rather than as a hired man. Those of us who have had dealings with these Boards know how very great is this need, and not only for the technical knowledge and training of the engineer, but also for the judicial qualities to which Judge Prouty so pointedly refers. I do not wish to be misunderstood here, so I repeat, a man is not qualified for this most important position because he calls himself an engineer. In fact, I doubt if any man should be entrusted with so much power as are these commissioners. But as long as we must have them we want all the safeguards available, and the engineering profession can supply one of the most important of these. In short, I believe that our public service commissions should be composed of common-sense men, broadly trained, broad minded, fair, and competent as investigators (an unusual qualification peculiarly lacking in our official investigators); and in each commission there should be men fully qualified in the theory and practice of the professions of engineering, law, business, finance, and accountancy.



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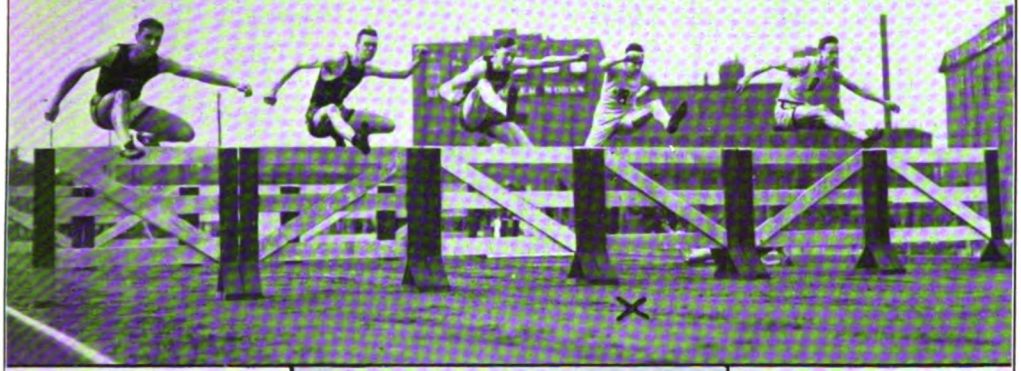


BOWDOIN -TECH MEET.

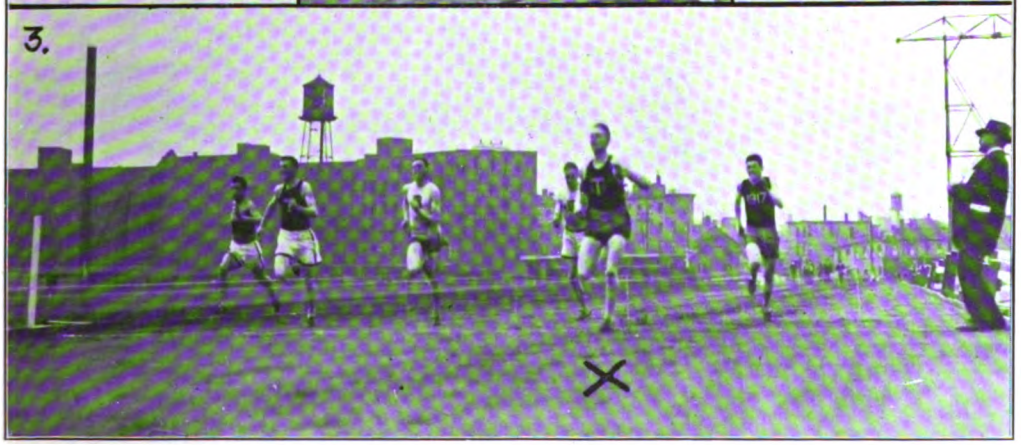
1. SAVAGE OF BOWDOIN WINNING HIGH HURDLES

2.

2. SAMSOM WINNING POLE VAULT

3. 100-YARD DASH. LOOMIS TIEING TECH RECORD.

3.



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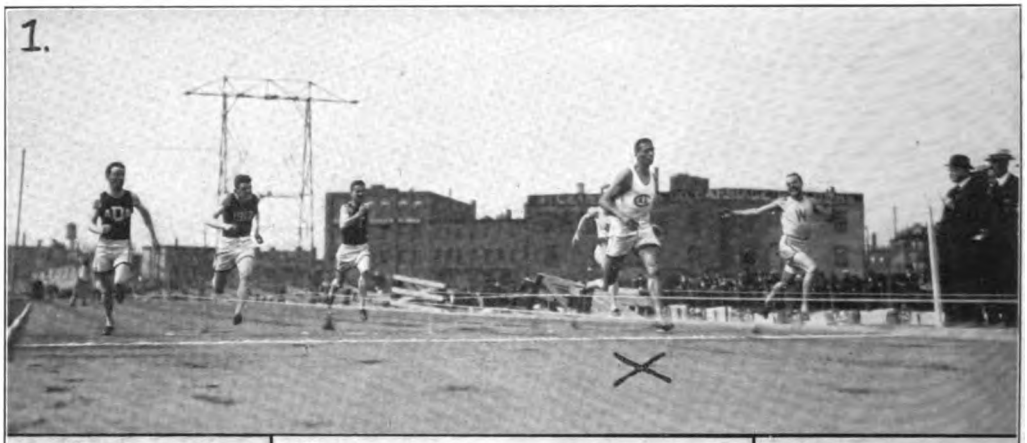

NEIAA MEET

1. HOWE OF COLBY WINNING 100-YARD DASH SEMI-FINALS.

2.

2. COOK OF TECH WINNING THE TWO MILE.

3. SAVAGE OF BOWDOIN WINNING THE HIGH HURDLES FINALS.

3.

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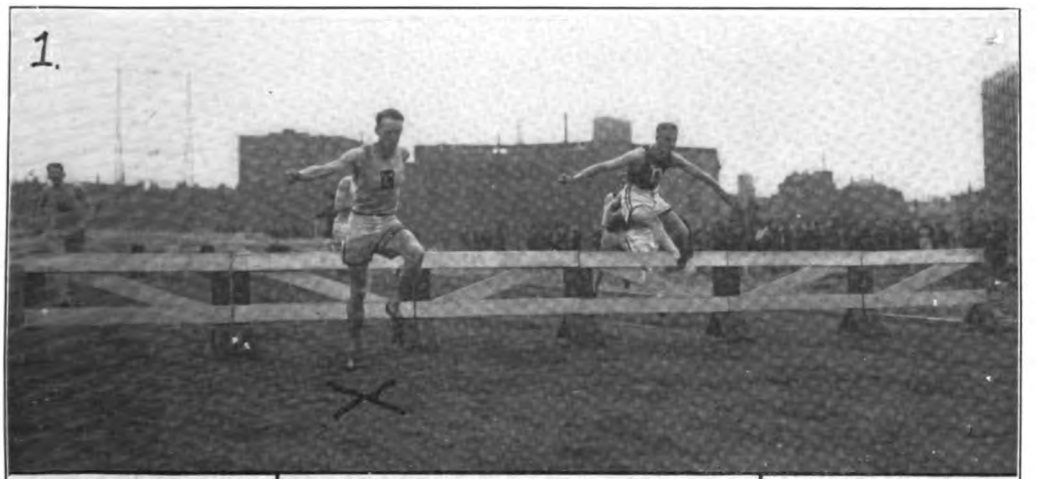

NEIAA MEET

1. SAVAGE OF BOWDOIN WINNING THE LOW HURDLES

2. RILEY OF DARTMOUTH WINNING THE QUARTER-MILE FINALS.

3. HOWE OF COLBY WINNING THE 220-YARD DASH FINALS.

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ALOXITE

An Abrasive for Steel Particularly

ALTHOUGH carborundum is a versatile abrasive which cuts many different substances quickly and freely, it is too hard and too brittle for steel. Steel is hard, close-grained, strong and tough. Therefore, the abrasive which can grind steel successfully must surpass it in hardness, compactness, strength, and toughness. Aloxite fulfills all of these requirements. Moreover, it cuts without heating the work or becoming heated itself.

Aloxite is the trade name for this peerless steel-cutting abrasive, which consists essentially of aluminum oxide. Like carborundum, it is a product of the electric furnace and is made by heating an ore containing this oxide with certain ingredients which are added to remove the impurities. As the ore comes to the furnace department, it contains alumnium oxide, iron oxide, silica, and several minerals. The objects of the furnace process is to free the aluminum oxide of all these substances. The ore is crushed, mixed with known amount of carbon to aid in the purification, and is then ready to undergo the refining process in the electric furnace.

The furnace is a box-like crucible with detachable sides, and is lined with fire-clay. The current is led in through two huge carbon electrodes which are suspended in the furnace and between which an awe-inspiring arc flashes. The aloxite furnace is, therefore, an arc furnace, while carborundum is produced in a furnace of the resistance type. The mixture is fed in until a gigantic pig of aloxite weighing several tons is formed. By feeding the charge directly between the electrodes, it is subjected to a temperature of maximum intensity. The temperature of the arc has never been determined with any degree of certainty, but some experts in high temperature measurements believe it will reach at least 6,500 degrees Fahrenheit. At this temperature all of the constituents of the ore are reduced to the metallic state except the aluminum oxide. Some of the resulting metals are volatilized while the iron and silicon unite to form ferro-silicon, which settles to the bottom of the furnace and is tapped off just after the run is stopped. Fortunately for the success of the process, the aluminum oxide is not reduced by the carbon under the conditions which hold during the furnace run. The process, therefore, assures a product which is free from impurities; but to make assurance doubly sure, the aloxite is subjected to further refining before it is graded.

The aluminum oxide as it emerges from its baptism in electrical fire is a product with all its properties raised to a higher power. Its hardness is made harder, its sharpness made sharper, its toughness tougher, and its compactness more compact. It is, moreover, stronger and heavier than the corresponding natural product. Corundum is the natural aluminum oxide; aloxite is the supernatural. Furthermore, the natural product is quite apt to lack uniformity in composition and in structure. On the other hand, the furnace product, which is

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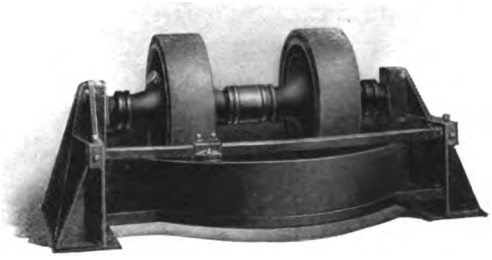
made by a process under perfect control, is absolutely certain to possess uniformity in both of these properties.

Aloxite, therefore, possesses every qualification that goes to make a good abrasive. It is strong, hard, compact, and tough—fast, clean, and cool-cutting. It breaks with a rough fracture that makes it easy for the bonding material and glue to take hold. To describe it briefly, it is a gem. And this statement is no exaggeration, for aloxite has the same chemical composition as the ruby and the sapphire. By accident of nature, however, the ruby and sapphire contain traces of other substances which give them their color and beauty. Aloxite itself is colored either a dark reddish brown or a bluish grey. The colors, however, are not bright enough to be beautiful. But the lack of color does not impair the abrasive properties of the furnace-made gem. It is interesting to note that the aloxite wheel is just a mass of rubies and sapphires, although its value rests in its practical, rather than in ornamental, use.



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FACULTY HONORS

I

ARTHUR AMOS NOYES

Receives Willard Gibbs Medal for Chemical Research

Editor's Note. A new department of "Faculty Honors" is started with this issue to The Technology Monthly. It is to acquaint the student with the work that is being done by various members of our Faculty, and with various honors that are conferred on them, which is perhaps the best gauge as to the manner in which their work is received by their own profession. We feel fortunate in being able to start this department, which will be run from time to time, with an account of the latest honor conferred on Dr. Noyes, one of America's foremost chemists.

AN exceedingly small fraction of the student-body is aware of the fact that in our midst is one who has this year received the very highest honor that can be bestowed upon an American chemist. To Dr. A. A. Noyes has been awarded the Willard Gibbs Medal for 1915. Each year one American chemist is selected by the Chicago Section of the American Chemical Society as having done, during his career, the most important services to the science. The medal thus far has honored S. V. Arrhenius, W. T. Richards, L. H. Baekeland, Ira Remsen and A. A. Noyes.

Arthur Amos Noyes was born in Newburyport, Massachusetts, September 13, 1866. He entered the Institute in 1881, took Course V, and was a member of K2S. He graduated from the Institute in 1886, and obtained his Master's degree the following year. After a year spent as assistant in analytical and organic chemistry, he went to the University of Leipzig, where after two years of study with Professor Wilhelm Ostwald he obtained the doctor's degree. Returning to the Institute he served four years as assistant and associate professor of organic chemistry and in 1899 was made professor of theoretical chemistry; in 1903 he became director of the Research Laboratory of Physical Chemistry. From 1907 to 1909 Professor Noyes was acting president of the Massachusetts Institute of Technology. He is at present a member of the National Academy of Sciences, and of numerous other scientific societies. During 1904 he was president of the American Chemical Society and served for many years as a member of its board of editors. He is a member of the editorial board of the *Zeitschrift für physikalische Chemie.*

In the presentation address Dr. Julius Steiglitz said:

". . . And tonight we are adding to the luster of the medal by bestowing it on another of those brilliant Americans, whose genius is fast making American chemical research in quality the peer of any in the world. Many of us will recall that when Arrhenius was here and told us his own picturesque story of the history of his theory, he remarked that the very finest work in developing his theory in the way of rigorous measurements was being done in this country

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in the research laboratory of the Massachusetts Institute of Technology under the direction of Arthur Amos Noyes. With accuracy as its goal and scientific honesty as its talisman, the laboratory of Dr. Noyes has produced classic after classic on the conductivity relations forming the basis of the theory of ionization. . . .

"Undoubtedly it was this same pressing need of accuracy that led Dr. Noyes into the monumental work . . . on the revision of the methods of qualitative analysis. . . .

"I cannot close this short review of some of the contributions of our medalist to our science without a grateful recognition of two other important forms of service other than original investigation. Dr. Noyes has been uniquely successful in associating with himself a group of great chemists, Lewis, Whitney, Washburn, Kraus, Bray, Tolman, Harkins are carrying the traditions of accuracy and thoroughness of his laboratory into all parts of our country, in technical as well as scientific fields, in work fertilized by their own brilliant ideas, characterized by the standards of the research laboratory of the Massachusetts Institute of Technology. In the second place, Dr. Noyes has been and is a great teacher of the young, the undergraduate chemist-to-be. Like A. W. Hofmann, in his day the greatest teacher of chemistry in the world, Dr. Noyes has insisted on presenting to beginners in chemistry the new physico-chemical theories in lucid, transparent terms, in persuance of this ideal, he has invented a long series of beautiful lecture experiments on physico-chemical relations—the best we have, which, like Hofmann's, are now incorporated, more or less consciously or unconsciously, into our best elementary courses. These lecture experiments, like the work on the theory of ionization, like the work on qualitative analysis, have already become classics of American chemical endeavor."

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MINING DISTRICTS OF NORTHERN ONTARIO

By ROBERT LIVERMORE, M. I. T.
Manager of the Kerr Lake Mining Co., Cobalt, Ontario

Editor's Note. This article by Mr. Livermore, who graduated from Course III in 1903 at the Institute, is the first of two articles on The Mining Districts of Northern Ontario. This first article describes the silver fields, while the next article will be on the gold fields of the same district.

THE mining districts of the Province of Ontario may be roughly divided into two classes: the precious metal, gold and silver producing areas, and the other mineral producing districts, such as copper, nickel, iron and the commercial earths. At the present time producing mines of the former class belong to the northern part, and of the latter to the southern part of the Province. This, however, is a general statement only, as deposits of the precious metals have been known and worked for many years in the older southern districts, while considerable deposits of the baser metals are known, and at least one profitable deposit of nickel is being worked in the north. Still, the division is correct for the purpose of this article, which is to describe in general terms the productive gold and silver districts, and the conditions of mining in them, with which the writer is familiar.

The precious metal mining districts may again be divided into two distinct groups: gold and silver; for unlike most of the western mining districts, there is a very clear line of demarkation between the two, since gold rarely occurs in any considerable quantity with the silver ores, while silver, although found to some extent in the gold bearing veins, is a by-product only. The chief reason for this is to be found in the fact that the veins of the two groups, though all in rocks of pre-Cambrian age, were formed under different geological and chemical conditions, and at different periods.

The silver deposits are all in or associated with the rocks now named from the district which contains the most important deposits, the "Cobalt Series." This series is of Huronian age, with later intrusions of diabase, and overlies unconformably a base of complex rock consisting of greenstones, altered slates and porphyries of the Keewatin age. The Keewatin rocks are not properly of the series, but important silver veins existing in this formation were affected by the same geological conditions as those responsible for the deposition of the silver ores in the Huronian. The Cobalt Series proper consists mainly of slates, pebble conglomerate, and greywacké. It was originally deposited by sedimentary action on the uneven Keewatin floor, and subsequently tilted, faulted and eroded, so that its thickness varies greatly, and its former horizontal bedding planes are rarely maintained in that position. Its sedimentary character is clearly shown in the waterworn pebbles of the conglomerate and the even stratification of the slate.

Subsequent to the laying down of the Huronian measures there was a great intrusion or eruption of diabase, which in the form of a huge sheet or sill cut through or spread over the entire series as well as the underlying

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Keewatin. This sill has been proven to be over five hundred feet thick. The generally accepted theory is that the shattering and fissuring of the rock which opened the way for the ore bearing veins took place by contraction when this eruptive cooled, and that the diabase itself was the source of the silver. Some engineers of repute hold that the fissuring was subsequent to the eruptive flow, and not directly due to it, and that the silver was deposited from deep seated solutions, in one or the other formation according to the favorable chemical conditions of the wall rocks. Faults are quite numerous, varying from mere steps in the bedding planes to throws of many feet. These seem in some cases to have influenced the deposition of the ore in the veins, notably in the vicinity of the great fault under Cobalt Lake, and in the South Lorrain district, where the ore bodies have usually been found near the faulted contact between diabase and Keewatin. The faults themselves, however, rarely form ore zones.

The ore bearing veins occur in all three formations: the basal Keewatin, the more recent Huronian, and the intrusive diabase. They are far more numerous in the Huronian than in the other formations, so much so that it has been the custom to measure the probable life of the district by the known areas of Huronian rocks. That this is not entirely the case is shown by the fact that very important deposits in both diabase and Keewatin, which have added largely to the total production, have been worked since the early days of the camp, and discoveries are still being made in these formations. In fact, since the Huronian area is distinctly limited both in surface area and depth, the best hopes for the future lie in exploration of these deeper-seated rocks.

In general it may be said that the veins occurring in the Huronian are far more dependable than those in other formations, and one fact is universally recognized, that a vein which carries ore in one of the three principal rock series named, will carry it in that series alone, and though the vein itself may continue in strength for some distance, it will rarely contain ore for more than a few feet in a different series.

The silver occurs in several forms; native silver, in sheets, masses and in fine combination with other minerals, being the most common form. Proustite, argentite and dyscrasite are also common. Closely associated with the silver are the cobalt compounds smaltite and cobaltite. It is from this mineral that the camp takes its name, as the prominent outcroppings of cobalt "bloom" attracted the first notice to the veins. Niccolite is nearly as common as smaltite, and is usually an ore bearing mineral. The commoner minerals, galena, and iron and chalco-pyrites are frequent in occurrence, but are never good indications of ore. The vein filling is almost invariably calcite and dolomite. Where quartz occurs it is rather a sure sign that no silver will be found.

In conjunction with the veins there is usually an impregnation of the wall rocks with silver, extending from a few inches to widths of many feet from the veins. In the early days little attention was paid to this feature, both for lack of methods for treatment, and because the high grade ore was so easily won; but with the partial exhaustion of the high grade, the low grade mill rock has become of increasing importance, and today a very large tonnage is handled in the very modern plants that

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have been erected as conditions warranted.

Erosion has played a very important part in the physical features of the country, due to the very great glacial action of past ages. Unfortunately for the miner it has not worked entirely to his advantage, for undoubtedly enormous thicknesses of ore bearing rocks have been eliminated. Still, it has not been all one-sided, for just as probably, ore formations formerly capped or concealed by barren rocks have been exposed to view by this agency.

EXAMINING SURFACE SHOWING IN WINTER

The physical aspect of the Cobalt country is one of low, rounded, rocky hills, rarely exceeding two hundred feet in height, formerly forest-clad, but now unsightly with stumps and brush. Numerous lakes make up a large part of the surface area, and often overlie parts of the mines. The altitude is about one thousand feet, and the climate dry and bracing. The winters are long and cold.

The Cobalt silver district so far overshadows the other silver producing areas of Ontario, that a description of its main features covers the whole subject. The Cobalt district proper covers an area some five miles long by two wide. While certain productive areas, such as the Casey-Cobalt mine on the north and the South Lorrain district on the south, extend its limits for over twenty miles, the mines of both the last mentioned places are simply isolated cases of ore deposition, to which the same features apply as to the parent district.

The district is served by the Temiskaming & Northern Ontario Railway, a government owned line which gives excellent service to the whole north country. This road is in fact the prime reason for the discovery of Cobalt. It was originally projected by the Ontario government to open up for settlement the fertile clay lands known to lie to the north and west of Lake Temiskaming, reaching far north over the height of land toward Hudson Bay.

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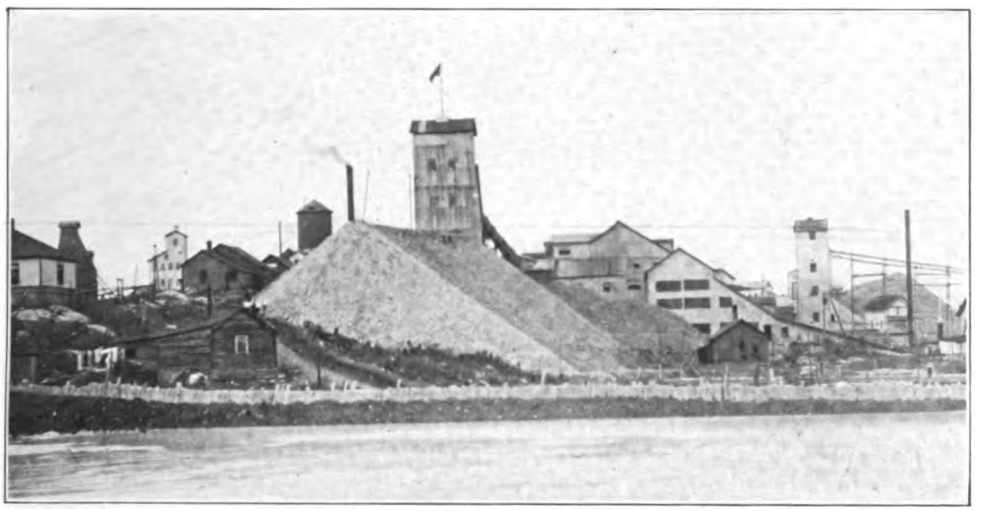
The first ore was found on the shores of Cobalt Lake, then known as Long Lake, in 1903, by employees of the railway. Not until 1904 was the importance of the deposits recognized, but when it was, a rush set in, and scenes of excitement and "wild-catting" usual to new finds prevailed. A strange combination of rough remoteness and accessibility was this rich silver camp in the heart of the northern wilderness, separated by many miles of untracked forest, yet to be reached in one night from the great city of Toronto by comfortable Pullman car. Today, only ten years after the time when none but the timber cruiser, the Indian or trapper traversed the wilds by canoe and portage, a town of thousands of people, with well built buildings of brick and stone, with electric cars and automobiles passing along its streets, stands on the site of the old forest. So swift is the progress of a prosperous mining community.

Cobalt has produced in the ten years of its existence more than 210,000,000 ounces of silver, and has paid over $60,000,000 in dividends. For the last five years the production has been maintained at nearly 30,000,000 ounces annually, and although there are signs that this figure is gradually decreasing, the output is still maintained at not far from its high mark. There are at the present time no less than sixteen producing and dividend paying mines in an area five miles long. In normal times there are 5,000 men employed in and around the mines, and probably 10,000 people in the district and neighboring towns are dependent directly or indirectly on the industry.



THE CONIGAS MINE

There are three main groups of mines in the district: those near and surrounding Cobalt Lake, where the town stands and where the first discoveries were made; those in the Kerr Lake district two and a half miles south; and those two miles farther south near the granite contact, known as the Temiskaming and Beaver Mines.

Of these, the first now derives its ore almost entirely from the Huronian measures, and is by far the largest in number of mines and productive area;

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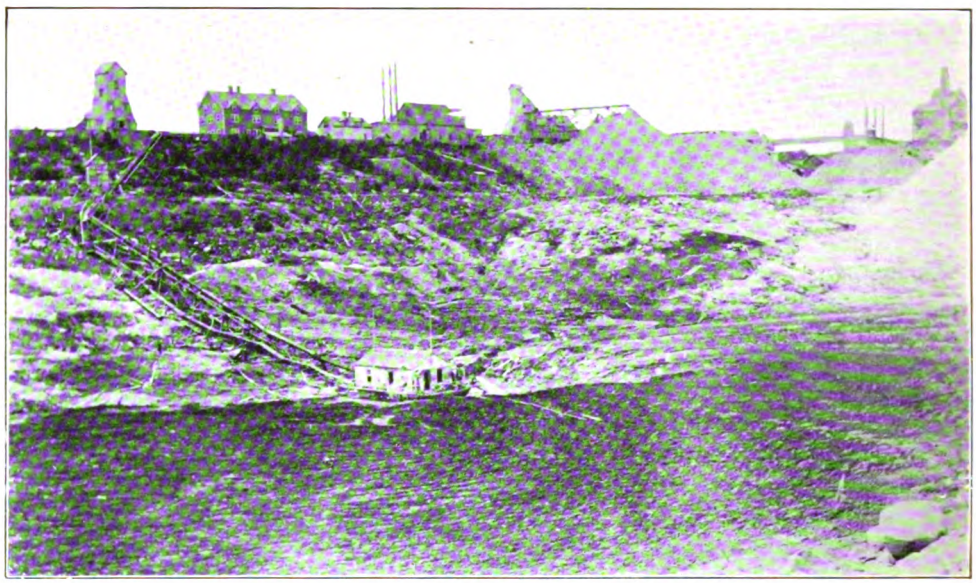
the second takes a large production from the Huronian, but also has had veins of great richness in both diabase and Keewatin rocks; the third, and smallest, has depended upon the Keewatin for its production up to recently, but of late has made some finds in the diabase which here underlies the Keewatin.

The Cobalt veins are narrow, rarely exceeding a foot in width, and are very irregular in all dimensions. They are, however, extremely rich, probably the richest silver veins ever uncovered. It is not unusual for carload shipments to contain four, five, or six thousand ounces to the ton. The characteristics of the veins make them exceedingly hard to estimate with much exactitude as to their future productivity. This uncertainty has hurt many of the properties from an investment point of view, and economically speaking, has operated against initial installment of efficient equipment, and use of long-sighted mining methods proper to mines of more certain future. In the course of years, greater familiarity with the "habits" of the ore has enabled engineers to make much more comprehensive estimates of the reserves, so that with the confidence time has brought, many of the early mistakes have been set right, and mining and treatment methods brought thoroughly up to date.



DRAINED BASIN OF KERR LAKE

The mining practice of Cobalt is not complicated. Shaft level, and overhead stopes are universal. The wall rocks are solid and on the whole little timbering is required. The ground is easily broken; and the ore is hoisted to the surface for sorting, where the high grade is picked on belts or bumping tables, the fines jigged for smaller pieces of high grade, and the rejects sent to the mills. About the only engineering difficulties met with underground have been those where the valuable deposits lay under water, where greater care has been found necessary in stoping and supporting

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the ground. At Kerr Lake, a body of water some 40 acres in area, and a hundred feet deep occurred. The managements of the two companies, parts of whose property lay under it, undertook to drain the lake by mounting powerful pumps on a scow, and pumping the 400,000,000 gallons of mud and water it was estimated to contain, out of the basin. This has been accomplished, and has thrown the formerly submerged territory open to prospecting and mining. The management of the Cobalt Lake Mine which lies under the lake of the same name has installed apparatus of similar nature and has commenced dewatering that lake also.

TEMISKAMING MINE

Surface prospecting has always been a very necessary part of Cobalt mining operations, since so many small, yet rich veins lie irregularly over it, which would be difficult and expensive to search for underground. This has usually been done by trenching through the drift material, but the Nipissing Mining Company, which has a large surface area, has tried the interesting and successful experiment of installing a powerful hydraulic plant which strips large surfaces bare of overburden at a minimum of expense.

Cobalt is not a "deep" camp. Two hundred feet is considered a very satisfactory thickness for the Huronian rocks, and the average is still less. The great number of veins and their richness have, however, greatly compensated for the lack of depth, since if ore is concentrated by nature on the surface it is that much more easily mined than lower grade ores which must be hoisted from greater depths at greater expense in equipment and elaboration of mining methods. This fact is too apt to be overlooked by the investor or engineer, who has always had impressed upon him the desirability of permanence with depth, and the reputation of Cobalt has in the past suffered accordingly. The continued productiveness of the district, however, has gone

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far toward re-establishing the confidence lost when its shallowness was first recognized. Naturally, depth of ore deposits is highly desirable, for lateral extension of the veins is obviously limited, and in the long run permanence depends upon the depth to which the ore will go. Signs are not lacking that this factor has still to be determined, as ore has been discovered and mined at quite respectable depths in the Keewatin and diabase, and the district is not without hope that its future will be assured by further discoveries. Up to the present, however, all discoveries are well within the thousand foot mark.

Almost all of the producing properties treat their low grade ores in either their own or custom mills. The milling practice varies between simple amalgamation and concentration, and straight cyanidation. The concentrating advocates claim that though a less extraction is made, the loss is offset by the lesser costs of treatment. Those who uphold cyanidation alone say that the extraction attained far more than balances the extra cost. With the advent of the 240-ton low grade mill of the Nipissing Mining Company, which does away with concentration entirely, and depends upon fine grinding with direct cyanidation, the latter practice has become generally recognized to be the best, and most of the mills are now using cyanide in their process.

Most of the mines have their own steamdriven power plants, but these are used simply for heating or for auxiliary supply during occasional shortages due to vicissitudes of climate. The main supply is bought from a custom power company which controls the huge water power on the Montreal and Matabitchouan Rivers, and furnishes both electric and compressed air power to the whole camp.

Labor is, on the whole, efficient, and of a good class of men. The rank and file are of all nationalities, with the native-born in the majority. The Nova Scotian gold miners were at first the only experienced machine men, but of late their places have been partly filled by foreign-born who have proved themselves adept. Finns and Austrian Poles are strong in numbers, and much to the credit of the Canadian temper, the latter have been permitted to continue at work without molestation, in spite of their nationality. Wages, in comparison with western, and with other camps of Northern Ontario, are not high, ranging from $2.25 to $3.25 a day, but conditions of living are easy and working hours are not long.

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A BOOK REVIEW

By KENNETH D. KAHN, M. I. T., '15

"METHODS OF METALLURGICAL ANALYSIS," by Charles H. White, Assistant Professor of Mining and Metallurgy, Harvard University and the Massachusetts Institute of Technology. D. Van Nostrand Company, Price, $2.50.

Unlike most of the engineering text books and handbooks of today, this manual is not wordy nor is it filled with irrevelant matter. It has the advantage of Van Nostrand's new style binding. It is compact, and is provided with round corners and small margins, making the volume condensed enough to be carried in the pocket and used in the laboratory.

The book is designed to follow immediately a course in qualitative analysis, the author being of the opinion that students who have had adequate preparation in qualitative analysis can take up metallurgical analysis at once without the intervening course in quantitative analysis such as is the usual practice.

Among the subjects treated in this concise but inclusive work are equipment of laboratory, selection of methods, sampling methods and apparatus, operations in analyses, quick methods of analysis of ore, estimation of sulphur, silicon, phosphorous, manganese, nickel, copper, tungsten, products, gold and silver, fuels, oil and some rarer elements. Among the newer subjects treated are copper in steel, cyanogen in commercial cyanide, gas analysis, testing of uranium ore, and estimation of boiler water.

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All manuscripts submitted for publication in the TECHNOLOGY MONTHLY AND HARVARD ENGINEERING JOURNAL should be accompanied by the writer's full name and address. Manuscripts not accepted for publication will be returned only if the author so requests. Photographs, drawings, etc., will be returned to the contributor immediately after publication.

Forms close the 28th of the month immediately preceding date of publication. Material specially arranged for may be received up to the fifth day following.

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EDITORIAL

FRESHMEN: WELCOME!

"A MAN is known by the company he keeps," says an old adage. Concerning the college freshmen it might read, "a freshman is known by the college he enters." What are the motives, then, which have influenced the freshmen in their choice of Technology, as opposed to other institutions of higher learning? These motives are the germs of what we are pleased to call the "Technology Spirit."

All of the influencing motives are centered around serious endeavor. A young man or young woman does not come to the 'Stute, with its world-wide reputation for hard, continuous study, for the purpose of having a "good time." It is more with the realization that Darwin's "survival of the fittest" applies to industry and science as well as to nature. Success demands the best of technical training coupled with life-long industry. And for success this training should commence with col lege life.

This is the ideal which influenced William Barton Rogers to found the Massachusetts Institute of Technology. It is the guiding motive that gave the Institute a reason for existence, that kept it alive and independent in the past, and that will lead it on to a more and more glorious future. In proportion as this ideal has been adhered to by our Alumni, it has meant their successes, often brilliant, and has made "Boston Tech's" reputation what it is. To repeat, it is the "Spirit of Tech," and it is to this glorious life that we welcome you,—Class of '19.

BRIGGS FIELD

THE proposition of giving to our athletic field at the New Technology a proper name will come up every year until it is settled, and settled right. And the question will come around with every Field Day.

That the New Field should be named in honor of Major Frank H. Briggs, '81, is not a new idea. His name was proposed last year as a fitting tribute to the wonderful interest he has long shown in the Track Team. For many years he has been on the advisory council on athletics. It is an open secret that he has rendered athletics invaluable services, both financially and by advice, has attended meets with unusual regularity, has aided the managers and the men by individual interest and has sent entire teams to meets at his own personal expense.

It is not too much to state that if it were not for Major Briggs our athletics would not be nearly so stable as on their present basis,—if indeed we had a track team at all. Technique 1916 took a step in the right direction in dedicating their beautiful volume to him. It was the very highest tribute they could pay him. And unless the Field at New Technology is named "Briggs Field" Technology will have failed in one of her greatest privileges, will have left unrewarded a long service which money could not buy, and prove to those who know the facts that Tech men fail in a sense of the fitness of things.

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FRESHMEN AND ACTIVITIES

MORE than one college graduate who has risen to importance in industrial life has remarked that the one regret of his college days was that he did not take a larger part in activities. It is a well recognized fact that the insight into human nature, which at Technology can be only attained by participation in student affairs, is of inestimable value in after life. It is because advancement in any of the industries is dependent upon two qualities: training and a knowledge of men. Professional training is studied at the Institute. Unless you get to know this mysterious and variable quantity known as human nature, you lessen your chances of success.

Tech students,—Freshmen in particular—as far as you as individuals are concerned, *this is the hour and thou art the man!* Five activities offer this necessary training, in which advancement is won by competition: Track Team, Tech Show Musical Clubs, The Tech and The Technology Monthly. What are you going to do about it?

OUR FOREIGN STUDENTS

FOR several years Technology has been able to claim a large percentage of foreign students in its student-body,—in fact, one of the largest percentages among American colleges. Why so many men from other countries should choose the Institute from the hundreds of colleges within our national borders is obvious.

Judging from the number of our own countrymen who see the advantages of the acquaintanceship of the foreign students by the number who make application for membership in the Cosmopolitan Club, we can say that but few are awake to this opportunity.

What are the motives that have actuated these men in coming here? China had a wonderful civilization of her own when the Pyramids were young. The science of mathematics was given to us by the Turks at the time of the Crusades. Spain and Italy at the time of the Rennaisance were the most advanced countries of Europe in civilization. The Hindus today are masters of metaphysics. Our foreign students do not come, surely, to study their own civilization and philosophy here. What then? They come to see how we have advanced and correlated other civilizations, and to see our processes for doing it. In short, they want to get our viewpoint.

Herein lies the great advantage of getting acquainted with these friends, our foreigners. A great many of us cannot even seen another American's point of view, let alone that of another race, totally different in its traditions and inheritances from our own. Without being able to see things, to a measure at least, as they look to alien eyes, we cannot fully comprehend what they say or do, or appreciate their finest traditions and philosophy. It is only in proportion as we can see another's point of view that we are broadminded.

These friends have a social as well as a student's life. A friendship with anyone of these is almost certain to reveal an interesting personality as well as revealing the finest traits of their various races. Their friendship is certain to repay a thousand fold the time spent with them.

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HARVARD GRADUATE NOTES

'10—Edward S. Wolston, who was married on November 15, 1913, to Miss Theodora L. Perry of Boston, is living at 623 South 5th Avenue, Mt. Vernon, N. Y. He is now with the S. K. F. Ball Bearing Company, 50 Church St., New York City.

'12—A. A. Prior has accepted an appointment as instructor in Electrical Engineering, at the Case School of Applied Science, Cleveland, Ohio. Mr. Prior was married on July 2, 1915 to Miss Madeline I. Taylor at Boston, Mass.

'12—T. R. Schoonmaker is a member of the Harvard Red Cross Unit which has done such noteworthy work in stamping out typhus fever in Servia. He will return when the Unit leaves on October 10th.

'14—G. H. Roosevelt has returned from Dawson City, Alaska, and is now with the General Electric Company, at Schenectady, N. Y.

'14—F. H. Beall, and C. C. Yates '15 are with the American Telephone & Telegraph Company, New York City.

'14—R. I. Goldschmidt is with the Locks & Canals Co., Lowell, Mass.

'14—C. H. Marsh has left the Turners Falls Co., Turners Falls, Mass., and is now employed by the Turner Construction Co., 11 Broadway, New York City.

'15—P. S. Donnell has been with the U. S. Coast & Geodetic Survey in Alaska throughout the summer.

'15—J. R. Ripley is at present employed by the Westinghouse Church Kerr Co. of New York City, as cost clerk on work at Sayre, Pa.

'15—C. J. Mackenzie has returned to take up his work as Professor of Sanitary Engineering at the University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

'15—C. E. Rogers has returned to take up his work as Professor of Civil Engineering at Trinity College, Hartford, Conn.

'15—Louis Arnold of West Roxbury was married on May 15 to Mrs. Emily Brownell Keene of New Bedford, Mass.

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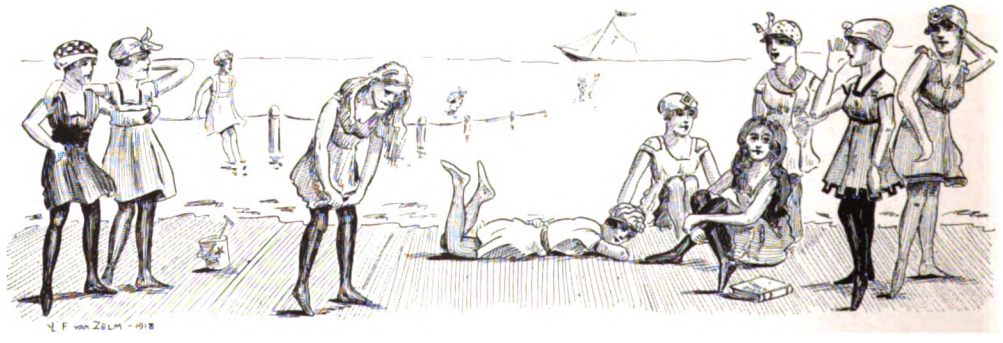
IN THE MOUNTAINS

IN THE COUNTRY



AT THE SEASHORE

VACATION: AS WE EXPECTED IT

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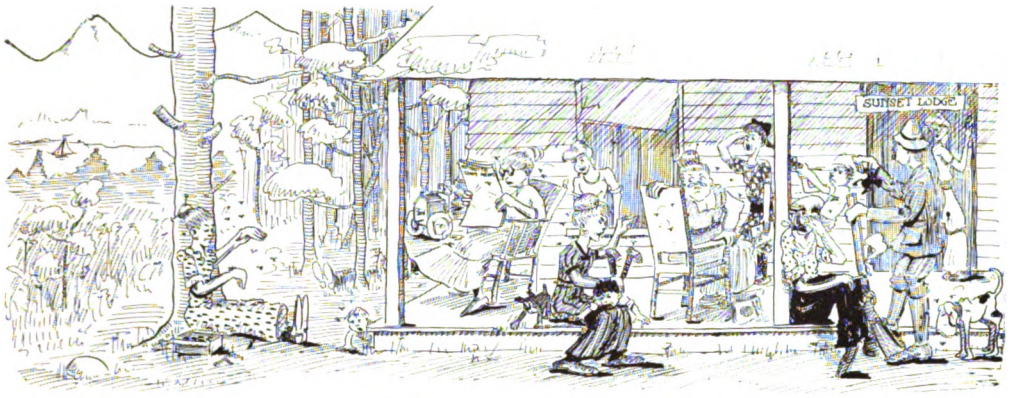

IN THE MOUNTAINS

IN THE COUNTRY

AT THE SEASHORE

VACATION: AS IT WAS

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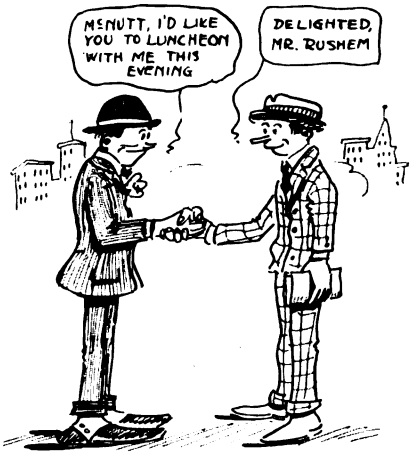
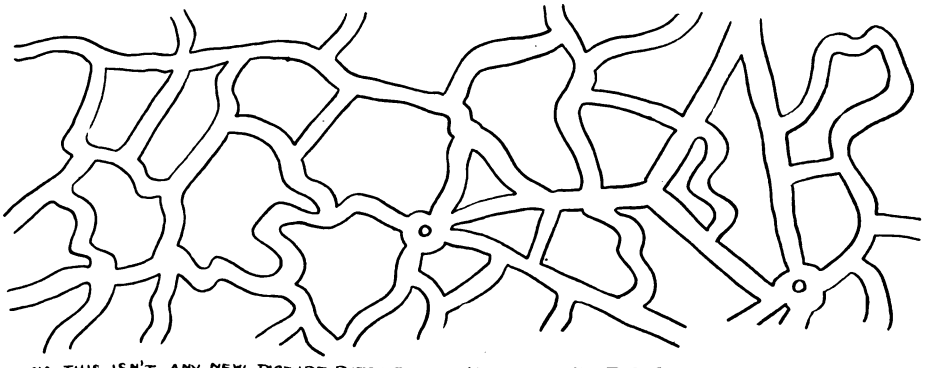
O'DEAR, O'DEAR, I JUST LOVE TO HEAR THE CONDUCTORS AND NEWSIES GET OFF THAT CUTE (DAM) **HAW**-VARD ACCENT.

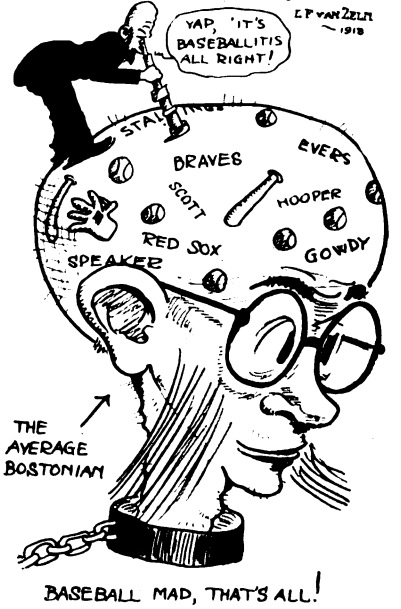


HOW CORDIAL AND PLEASANT THE UPPER CLASSMEN ARE!



NO, THIS ISN'T ANY NEW PICTURE PUZZLE, NOR ANY NEW WALL PAPER DESIGN – MERELY A BIRD'S-EYE VIEW OF BOSTONS THOROFARES – ISN'T YOUR IMPRESSION THE SAME TOO?

BOSTON CAN BRAG ABOUT SOMETHING, THO– SHE DOES HAVE SOME GOOD LOOKING GIRLS — WORTH LOOKIN' OVER ANYWAY, HEY BOYS?



BASEBALL MAD, THAT'S ALL!

IMPRESSIONS OF A FRESHMAN

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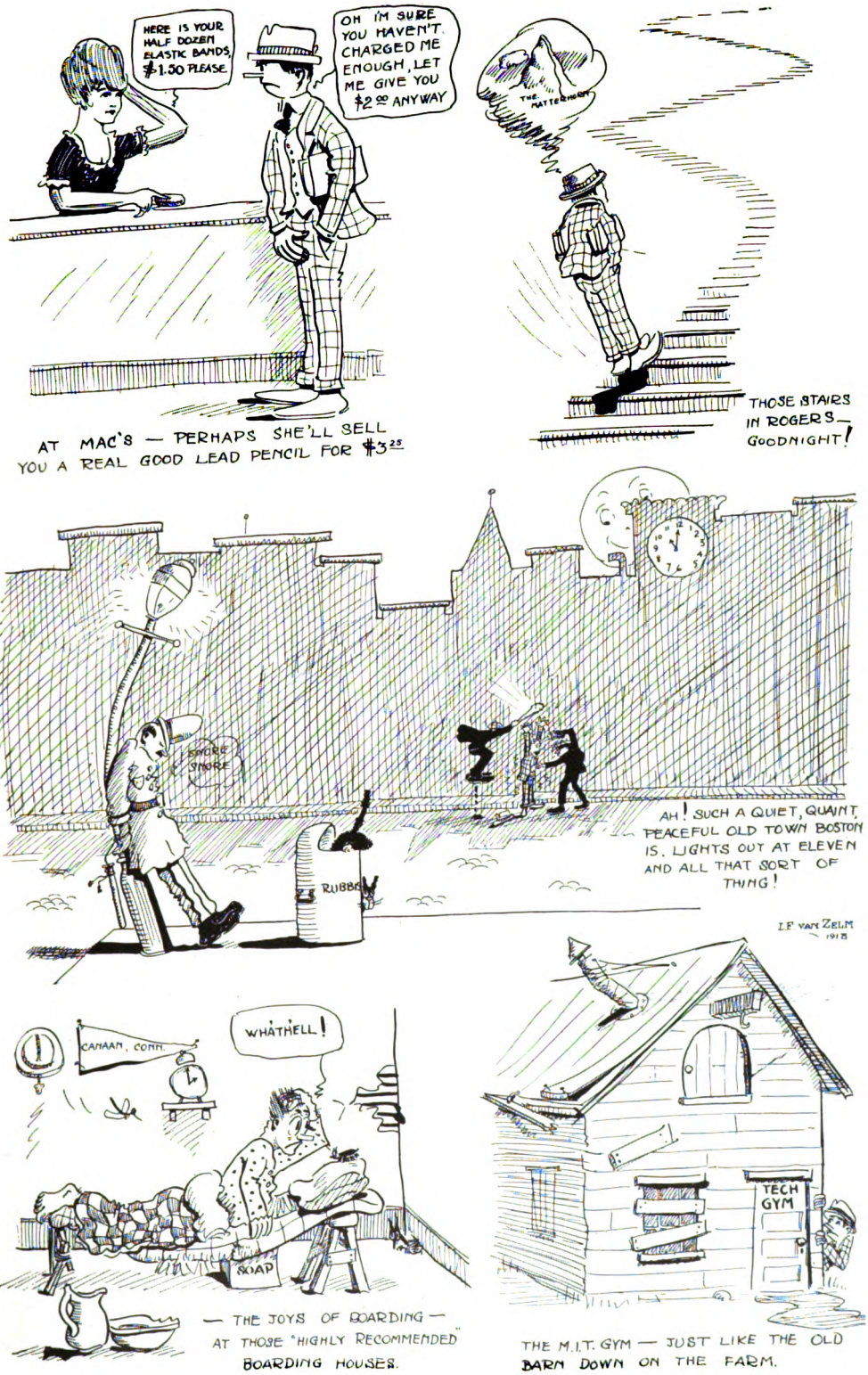

MORE IMPRESSIONS OF A FRESHMAN

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THE KALENDAR

NOVEMBER

1. Laboratory utensils scheduled for use in M. I. T. Chemical Department during winter of 1912-1913, arrive, 1915.

2. Great Pyramid, which is really a bomb proof structure, erected, B. C. 3700.

3. Report is circulated that the 191X relay team has broken the record. Several 191Y men denounce the report as false.

4. Mexican gladiators overrun the Institute. There are none in the rooms occupied by the Upperclassmen, however.

5. An old resident standing on Technology (formerly Harvard) bridge wonders what asylum has disbanded as the Tech P-rade progresses to Briggs Field.

6. Many studes on awakening feel glad that Field Day and Tech Night come but once a year. Can *you* guess why?

7. The Porcelain Tower, Nankin' destroyed by rebels, 1860.

8. The price of porcelain ware at the chemical supply room is advanced because of the above report.

9. Boston Post first issued, 1831.

10. Boston Post considered a newspaper somewhere, 1915.

11. Glass intended for glass blowing at M. I. T. "is prematurely blown into the North Sea"—, 1914.

12. The student-body becomes aware that the General Registration Act has been passed.

13. Many Tech men, especially Froshes contemplate rebellion at the thought of a repeated registration.

14. Several men propose to have the Institute Committee protest at more than two general registrations per year.

15. On discovery that the General Registration Act was passed in 1836, and not in 1915, all of the above excitement subsides.

16. Law of Gravitation discovered by Newton, about 1665. Charlie Cross believes the said law to still be effective in 1915.

17. The Designs Act, 1850. Frosh, studying Freshman Logic, contends that designs cannot act.

18. The Transit Instrument invented, 1689. So far this instrument has not simplified the Boston Elevated's Dudley Street Station.

19. Boston, capital of Massachusetts, built by the British, 1639.

20. Boston considers itself the "Hub of the Universe," 1639.

21. After 276 years and 1 day Boston fears it will cease to be the "Hub of the Universe" when Tech moves to "Nusite."

22. First fire-engine invented at Nurnburg, about 1660. This same engine is said to be in use in Boston at the present time.

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23. Sophomore class petitions that drill be made compulsory for both Freshmen and Sophomores, 1923.

24. New Haven, the seat of Yale University, purchased from Indians, 1637.

25. The donator of over 1000 libraries upon whose windows could be inscribed the words "Presented by Andrew Carnegie," born, 1837.

26. The first street railway car exhibited and operated, 1832. It is operated at present on the Boston Elevated lines.

27. Henry A. Rowland, one of the innocent causes of the present unpopularity of the study of physics at M. I. T., born, 1848.

28. Cass Gilbert, '80, graduate of the greatest scientific school, and architect for the Woolworth Building, born, 1859.

29. Upperclassmen show startling regularity in attendance in drawing rooms and laboratories. (Two more days for making up "Ds.")

30. Samuel L. Clemens, the man who made Mark Twain famous, born 1835.

First Frosh—"My father has a fine cedar chest."

Second Frosh—"That's nothing; my father is a veteran and has a hickory leg."—Dartmouth Jack o' Lantern.

Prof.—"Did you take an exam. today?"

Soph.—"No; is there one missing?"—Ex.

Lady to unshaven boarder.—"See here, young man, you will have to shave oftener, you've worn out nearly all the pillows in the house."—Ex.

Father to son who has brought home a poor report card—"Why is it that you always have E's and F's on your card, my son?"

"Well, you see E stands for 'excellent' and F stands for 'fair.'"

"Why the little girl across the road seems to get A's all the time."

"Well, you see A stands for 'awful.'"—Ex.

Frosh—"The preacher at church this morning said that neither the devil nor hell was mentioned in the Old Testament."

Soph—"What of it?"

Frosh—"Well, he claims that, there being no mention of either in the Old Testament, there cannot be either a devil or hell."

Soph—"That's no proof, the Old Testament doesn't mention physics either."—Lehigh Burr.

AND HIS MOTHER WAS A MURPHY

Frosh (at a hardware store)—"I haven't any money with me. May I charge this battery?"

Clerk—"Whatye think ye are, a light brigade or a regiment of Cossacks?"

PRISONER HANGS HIMSELF WITH SUSPENDERS

Pants himself to death, so to speak.—Ex.

LAMPED IN A RURAL CEMETARY CARVED ON A TOMBSTONE!

"Here lies Abraham at rest, with Mary Ann upon his breast."

Just below, written in chalk: "It's pretty soft for Mary Ann, but pretty tough on Abraham."

COUNT WINS SIX GIRLS, THEN FLEES

We prefer the fleas, too.

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THE PURPLE COW'S VERSION OF AN EARLY MARCH

Old John Winthrop (Class of 1621) rolls out of bed at 7.55 on a typical, tropical, slushy New England winter morning, while his alarm clock (brought along from England on the *Mayflower*) rattles in fiendish glee over his bed. Outside, the campus presents a picture like a futurist painting of "Springtime on the River Nile"—with stray Freshmen knee-deep in slush instead of crocodiles. Winthrop '21 turns on the shower and remarks—in his quaint old English spelling—to his godly Puritan friend, Praisegod Waite, '22—"Beyond peradventure, thys doe be onne helluva day, dear brother!"

And Praisegod bellows back from the bedroom: "Where ye devil dost think yte my galoshes be, Brother Winthrop?"

And then, just about that time, Winthrop, '21 turns the hot-water spigot instead of the cold-water spigot in the shower-bath, and burns himself and swears, and the Chapel bell starts into twos, and John Alden '24 (freshman) pipes up the stairs:

"Dear brethren, ye must show some pep, or verily I doe fear me yt ye cannot reach ye meeting-house!"

"Hell!" says Brother Winthrop, hopping out of the shower, and reaching for a towel. "I must to ye Dean's. I shall be over-cut, brother!"

"Nay, dear brother," yells John Alden, from his bedroom, brushing his teeth, washing his face, combing his hair, tying his necktie, putting on his shoes, throwing on his Puritan doublet, grabbing half a ton of books, and casting a sentimental glance at Priscilla's photograph on the bureau. "Nay, dear brother, be not wroth. Trust in ye Lord yt we may at least get breakfast at Gus's."

And then Winthrop '21, and Waite '21, and Alden '24 slam the door, curse the mud, grab their blunderbusses and dig for Chapel, taking pot shots at the Indians as they run.

AT NIGHT

At night—
A little after dark—
A quarter after eight—
I stroll down to the park—
I keep a date
At night.

At night—
A little maiden dark—
A little over weight—
Goes strolling in the park:
She keeps a date
At night.

At night—
I have a little lark—
A little tete-a-tete:
Before I leave the park
It's pretty late
At night.

At night—
(I venture the remark)—
Her nose ain't very straight:
She's homely—but it's dark—
That's why I wait
Till night.—Purple Cow.

Mabel—How are you getting on at college, Percy?

Percy—Oh, all right. I'm trying awfully hard to get ahead, you know.

Mabel—Well, heaven knows you need one!—Judge.

Omar—I find that the dove of peace is closely related to the great ant.

Fatima—But, say, the great ant is extinct.

Omar—That's just it.—Lehigh Burr.

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DEEP

Tut—Say, old man, I don't know what is the matter with me lately; I can't seem to sleep mornings between three and four.

Tat—Can't blame you a bit. I couldn't sleep myself with so many in a bed.—Punch Bowl.

Motorist (to companion, male)—I've lost the road. Let's ask those two girls over there.

Companion (after glance at girls)—Great guns, no! They wouldn't know; they're not pretty enough!—Punch Bowl.

"Save me," murmured the fair damsel, as she fell into the arms of her ardent admirer. Being an economical man he did so.—Penn State Froth.

Dolly—I'm surprised at you, sister. How many times did you let Jack kiss you?

Molly (meekly)—I don't know.

Dolly—I should think you would. It was going on right under your nose.—Jester.

"Tomorrow, gentlemen," said the professor in a lecture on taking notes, "I will bring in my cards and show you my card system."

Voice—O. K. Doc., fetch some chips and we'll have a regular party.—Punch Bowl.

HOW ABOUT "PULLED"

"Don't you dare touch me, Officer! I wear Prunelle Corsets and cannot be pinched."—Harvard Lampoon.

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This one comes from Pennsylvania, but we think it fits nearer Trinity Place.

"OUR COLLEGE SONG" REVISED AGAIN

(As we would sing it but for patriotism)
Come, all ye hopeful Freshmen now,
To "Vic" and White House, too;
Sit down prepared to feel your worst
While eating bread and glue.
Fair Harvard has her mess hall,
Old Yale her commons, too;
But at dear Pennsylvania
We dine on hash-house stew.

Chorus (All rise as when leaving lunch counter in disgust):
Hurrah, hurrah, 'tis in vain I jaw,
Hurrah, maybe some day we shall see
A hall for all, hurrah, a hall!
A hall for our appetite's glee.

One odor's in the gravy thick,
Another taints the eggs,
But when together both exhume,
We nearly "kick the kegs."
We ask no other menu,
No other bill to pay;
We only ask to dine within
A commons every day.

Cho. (Waving hats to insure better ventilation):
And now through all four years to come,
To swallow we shall fight,
And get new inspiration from
The vacant commons site;
And when from martyred college days
We say a last adieu,
Our indigestion shall call back
The hash-house bread and glue.
Cho. —This time violently, to get the taste out of the mouth).

P. S.—If you don't like it, blame it on the Busar—he's used to it.

—D. E. M., in the Punch Bowl.

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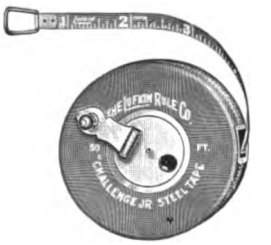

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SAGINAW, MICH., U. S. A.

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A sixteen-year-old when she first saw
the Follies,
A dearly delectable innocent miss,
Bewildered 'twould seem when away
from her dollies,
prised cited jumped like
Sur- ex- round
and she this.

Three years have gone by, she's some
runabout racer,
A dolled-up and daring, dear fox-trot-
ting miss.
With college-acquired shock absorbers to
brace her
SheisitsthrutheFolliesofFifteenlikethis.

—Medicine Man.

LITTLE TALES OF THE WAR

There had been quite a barbecue in camp. The Chinese cook had had a haircut. On all sides was heavy firing and the youthful drummer was quite non-plussed, not to say misused. At home the family practitioner had always warned him against lead poisoning, and now this rain of hot lead froze his blood. This rendered the bending of his limbs quite difficult, and gave the boy a rather formal appearance. A few feet away a private stood upon a gun-carriage supported by a Saturday Post. The next instant a dart from the enemy's aircraft fell directly upon him and he stood riveted to the spot. This was too much for the boy, who took up his drum and beat it.—Cornell Widow.

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For complete information regarding Model 310 Wattmeters and Model 329 Portable A. C. Polyphase Wattmeters write for Bulletin No. 2002. Other models in this group are 341 A. C. and D. C. Portable Voltmeter, described in Bulletin 2004, and Model 370 A. C. and D. C. Portable Ammeter, described in Bulletin No. 2003.

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A COMPLIANT VICTIM

Waiter—Will you have a fifteen-cent cigar, sir?

Guest (at New York hotel)—Yes, if it doesn't cost more than a quarter.—Life.

If I might hold that hand again
Clasped lovingly in mine,
I'd little care what others sought—
That hand I held, lang syne!

That hand! So warm it was and soft!
Soft? Ne'er was so soft a thing!
Ah, me! I'll hold it ne'er again—
Ace, ten, knave, queen and king!

—Lehigh Burr.

Josh—Is she refined?

Frosh—I should say she is. She won't even read coarse print.—California Pelican.

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(As exemplified in the life of the College Man)

VIRTUE.	VICE.
Class banquet (attendance at)	Class Banquet (condition at)
Study (of the Wisdom of the Ages)	Study (of the other sex)
Eating (at regular hours)	Eating (P-nuts in class)
Talking (philosophical dope)	Talking (the usual line of prevarication)
Walking (with the Walking Club)	Walking (on Chestnut St.)
Dancing (the Polka Waltz)	Dancing (Fox-Trot and Bunny Hug)

E. L. H., in the Punch Bowl.—

First Prehistoric Man—How did y' happen to croak Flintaxe?

Second Prehistoric Man—Aw, he told me he'd heard a new Ford story.—Yale Record.

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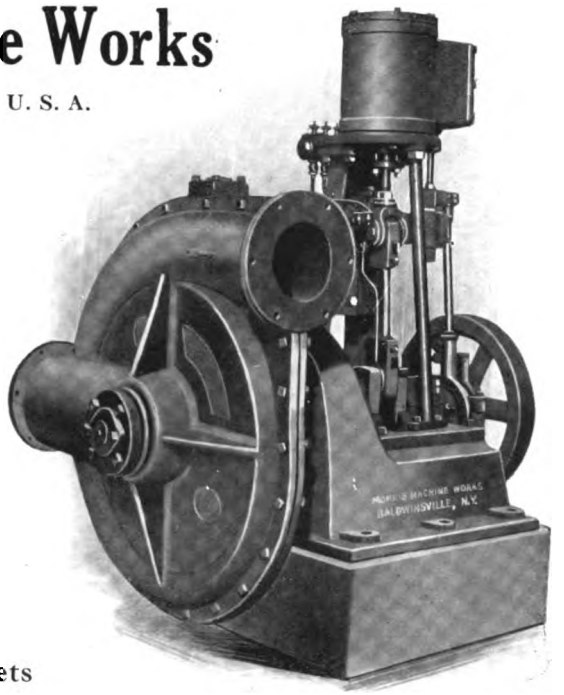

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THE IDEAL

Girls may come and girls may go,
But some girls leave us never,
The ideal girls they're in our minds,
And only (?) there—forever!
—Siren.

SENIORS!

Prof.—"Your thesis is excellent."

Stude (absently)—"It took him a week to write it."

Prof.—"What!"

Stude (waking up)—"I mean the guy who typewrote it."—Jack O' Lantern.

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Mr. Oldboy—Ahem! What ar' ye doin' there?

The Burglar (removing valuable painting from wall)—Hold steady now for a minute and look pleasant! I'm taking your picture!—Punch Bowl.

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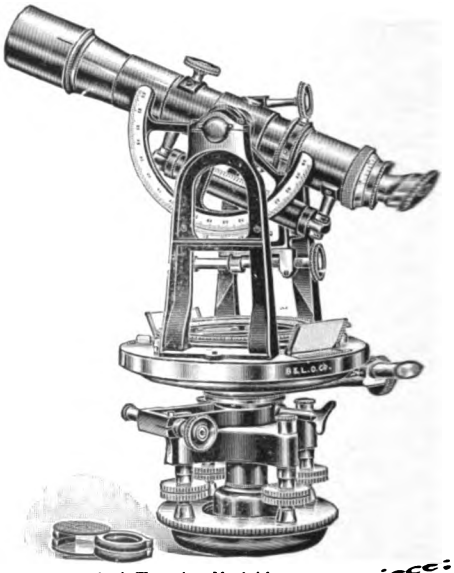

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White Sulphur Springs, W. Va.

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"I see you have been here before, Miss."
"How know you that, my gentle swain?"
"You must have known B. & M. service;
For I see you have brought your own train."—Purple Cow.

The poet sighed for he'd tried and tried
To find a word to rhyme with month;
When a mathematical friend of his,
Suggested $X\ (^{N} + {}^{1})$th.—Cornell Widow.

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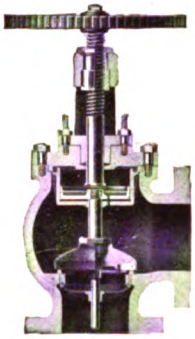

Fig. 293
Sectional View of Automatic Stop and Check Valve, Angle Pattern

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Entered as second-class matter at the post office, at Boston, Mass. Published monthly during the college year by the students of the Massachusetts Institute of Technology. Publication office, Technology Union Building, 42 Trinity Place, Boston. Harvard Editorial Office, 218 Pierce Building, Cambridge, Mass.

Mail Address: Technology Monthly, M. I. T., Boston, Mass.

Phone Back Bay 2180, Private Exchange

Subscription rate, $1.50 per year; 25c. per copy. Advertising rates upon application

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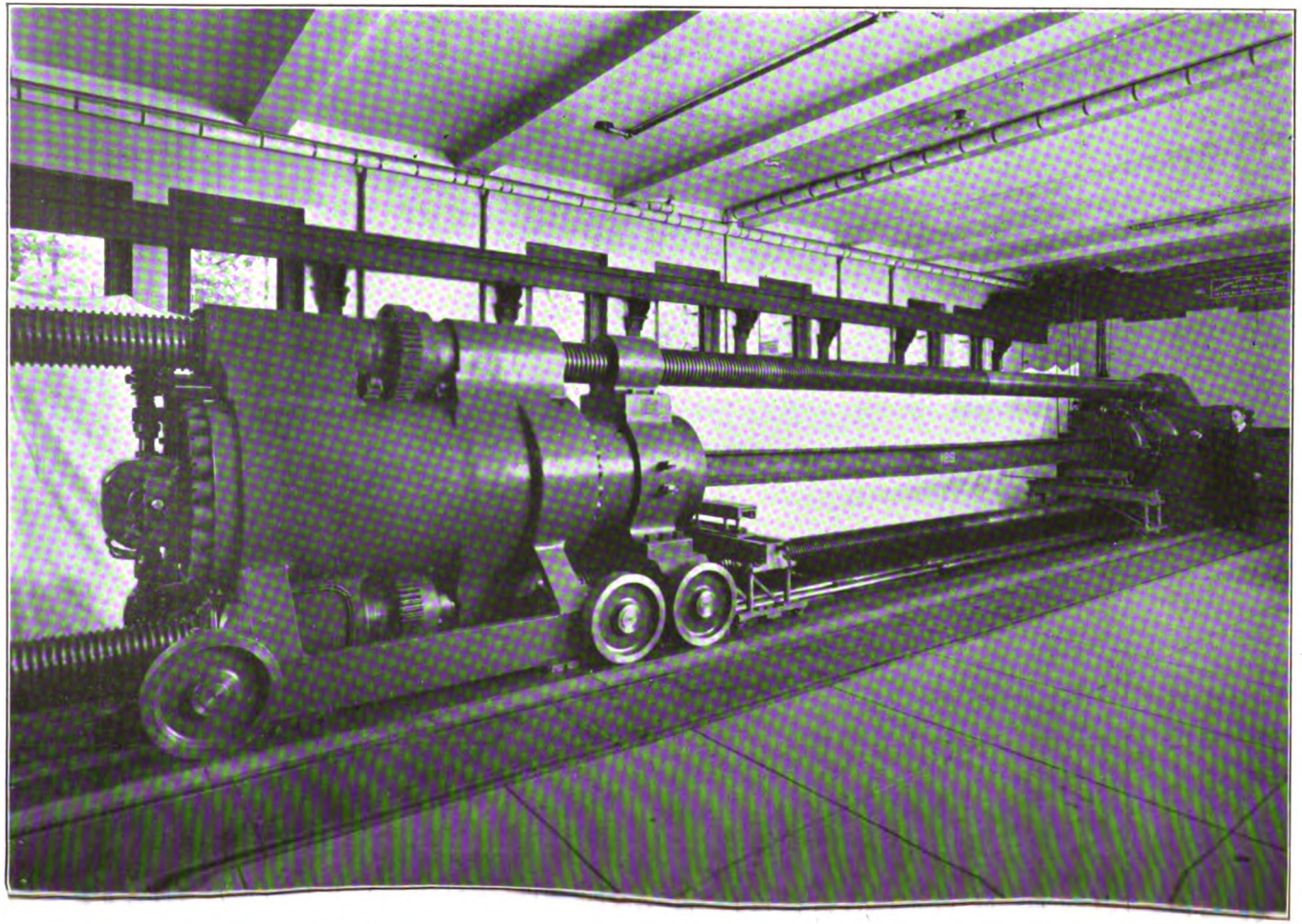

The Present Work of the Bureau of Standards

TENSION AND COMPRESSION TESTING MACHINE — CAPACITY 1000 TONS

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THE TECHNOLOGY MONTHLY
AND HARVARD ENGINEERING JOURNAL

VOL. II BOSTON, MASS., DECEMBER, 1915 NO. 5

THE PRESENT WORK OF THE BUREAU OF STANDARDS

By MAYO DYER HERSEY, M. I. T., '10

Editor's Note. Few Tech men realize the tremendous amount of technical research and scientific investigation that the Government is doing to lessen their future work. Mr. Hersey here gives an excellent idea of this work.

This article has been approved for publication by the United States Government.

THERE is a rapidly growing branch of the government service at Washington, namely the Bureau of Standards, which does for the manufacturer what the Department of Agriculture does for the farmer. It is an institution of applied physics, similar in scope to the Physikalisch Technische Reichsanstalt of Germany, or to the National Physical Laboratory of England.

All the principal nations have provided some means for carrying on governmental work of this sort, the importance of which is continually increasing. Thus, France in the later 70's established in Paris the Laboratoire d'Essais, the first director being the noted engineer, General Morin. The Laboratory was soon after visited by Helmholtz who immediately organized, on a still larger scale, the widely known Reichsanstalt at Charlottenburg. To supplement this work along engineering lines there is the magnificent Prussian Materialprüfungsamt at Gross Lichterfelde, another suburb of Berlin. The National Physical Laboratory at Teddington was established about fifteen years ago; the notable researches on aerodynamics carried out there will be the first to come to the minds of Tech men. The United States Bureau of Standards, an outgrowth of the Office of Weights and Measures of the Coast Survey, but now under the Department of Commerce, was established thirteen years ago. Recently the Eidgenossisches Amt für Mass und Gewicht at Berne, Switzerland, has moved into more commodious quarters where experiments comparable to those of all these other Laboratories can be undertaken; the strictly engineering work of the federal government being done at the Technischen Hochschule in Zurich. In Germany and Switzerland, then, the

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fundamental physical researches and testing of precision instruments are done in one institution, and the testing of materials in another; but in France, England and the United States all this work is combined. Two years ago, when the writer had just been visiting these institutions and had collected quite an armful of pamphlets, a distinguished gentleman, a citizen of Florence, enthusiastically expressed his interest in these data and his intention of urging the development of a similar institution for physical testing and research in Italy. Doubtless also the other great countries, such as Russia and Japan, with which the writer is not familiar, are progressing along this same line.

It is natural that our Bureau should be called the Bureau of "Standards" not only because of its historical origin, but also because this growing need for precise testing and research, which necessarily follows in the wake of the present day trend toward scientific and technical efficiency does center itself about the question of standards

FOUR KINDS OF STANDARDS

But the meter and kilogram are not the only standards involved. There are, to quote the Director, four quite different sorts of standards with which the Bureau is concerned; standards of measurement, standard values of physical constants, standards of quality and standards of performance.

The work with standards of measurement consists in the construction and intercomparison of the concrete standards, of various grades of accuracy, representing the units of mass, length, capacity, pressure, temperature, illumination, electromotive force, resistance, etc. Allied to this is the calibration of measuring instruments—ammeters, barometers, current meters, gas meters, hydrometers, pyrometers, scales, thermometers, viscosimeters, watches, etc. There are certain fees for testing such instruments, which are submitted in great quantities by manufacturers, universities, engineers and the public generally.

The researches on physical constants and other fundamental problems of the same nature include, to mention only some of the work which is now in progress or but recently completed, the determination of the mechanical equivalent of heat, specific heat of copper, heat of fusion of ice, standard wave lengths, value of the Faraday and melting points of the elements. Such investigations often entail a re-examination of the underlying theoretical principles and lead to results of permanent scientific value.

Nowadays the standard of quality demanded in a material is specified by its definitely measurable physical properties, such as density, thermal expansivity, resistivity, permeability, viscosity, color, turbidity, radio activity, tensile strength and the like. By these tests, supplemented oftentimes by chemical tests, the Bureau determines the useful qualities of a wide variety of materials, such as asbestos, bronzes, cement, cork, cotton seed oil, glass, ink, paper, paint, porcelain, rubber, sugar, building stone, structural steel, timber, tracing cloth, twine and textiles. The materials used in the Panama Canal were first tested at the Bureau.

The testing of structures or machines to see if their strength or capacity or efficiency meets the desired standard of performance is a natural sequel to the testing of materials. The Bureau has thus tested differently built up steel columns, wire-glass skylights

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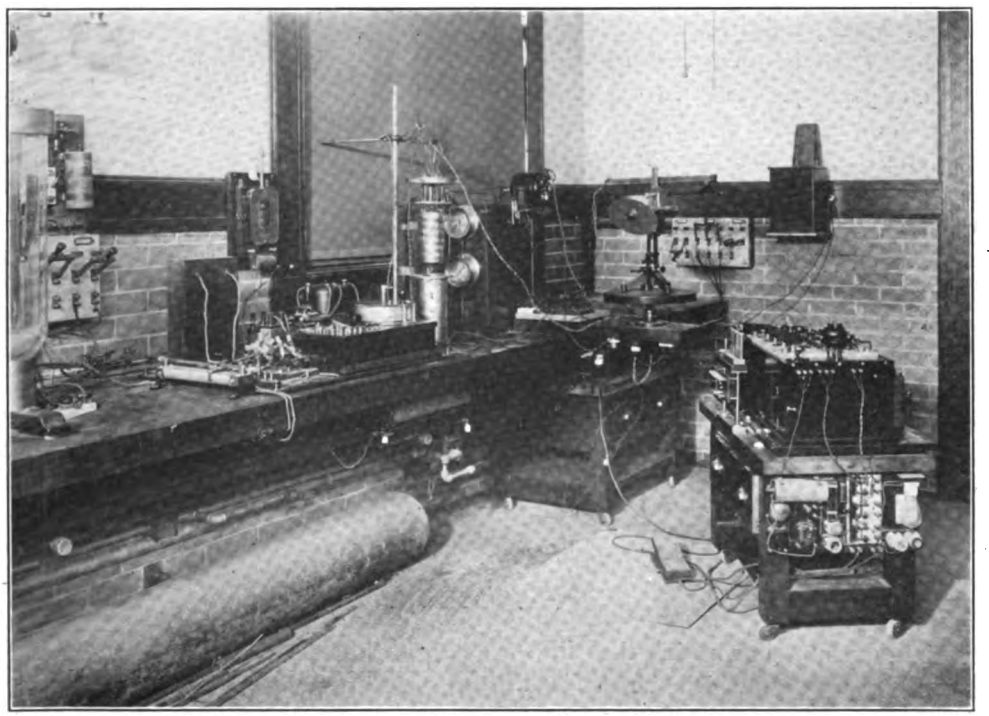
periscopes for submarines, steam radiators, vacuum sweepers, electric fans, fuses, fusible boiler plugs and internal combustion engines.

FIELD WORK

The Bureau's work is not confined to the laboratory: important services have also been rendered by field work, conferences, consultation and correspondence. For example, the Bureau has a test car going about the country standardizing the railroad track scales used in fixing the price of enormous quantities of grain, coal, etc. The car carries, kangaroo fashion, a smaller truck of accurately known weight on which a graduated set of weights can be loaded, aggregating the weight of a freight car. Again, for nine years now, an annual conference of weights and measures officials from the states and cities has met at the Bureau and done much to secure better local inspection and uniformity in state laws. Finally, a part of the time of the Bureau's experts is devoted to furnishing, free of charge, up to date information regarding physical and technological facts and methods asked for by manufacturers and investigators every day.



"ANEROID CALORIMETER" USED IN DETERMINING REFRIGERATION CONSTANTS

TYPICAL PROBLEMS

To make these generalities more intelligible, two or three typical problems may be traced through in detail. Take, for example, the recent determination of the heat of fusion of ice by Dickinson and his associates in the heat division. Why was this done? To meet the needs of refrigeration engineers. It is part of an extended program of related investigations under-

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taken at their request. Previous determinations were not in good enough agreement for present day practice. The difficulties surmounted in trying to sufficiently diminish the sources of error, as well as the two independent methods used to get a reliable result, are described in Scientific Paper No. 209. An interesting by-product of this work was the development of a calorimeter filled with solid copper instead of with water; it is called an "aneroid calorimeter" and shown in the illustration on page 7. The two pressure guages in the picture are part of the low temperature thermostat in which the calorimeter was placed. The desired temperatures were maintained by fizzing off liquified carbon dioxide through a valve into the surrounding coil of pipes. The carbon dioxide comes over from another building along with the service pipes which convey hot water, cold water, iced water, brine, gas, compressed air and vacuum to all the laboratories.

As a second example consider the determination of the melting points of microscopic samples of rare elements. To accomplish this, Burgess devised the instrument shown in the illustration on page 9, which he calls a micropyrometer. The specimen is set on a little polished platinum strip at P, which is electrically heated inside a small evacuated furnace. In the eyepiece of a microscope at L is placed, just as in the Holburn-Kurlbaum pyrometer, a miniature electric lamp. The observer looks down at the specimen through the cover glass C, and, while he watches it melt, he makes a "color match" between the image of the filament and that of the specimen by regulating the current through the lamp. Having standardized the instrument melting temperatures are gotten simply by reading the milliammeter. See Scientific Paper No. 198.

Finally, as an example of practical theoretical work, consider Buckingham's investigation of dimensional reasoning. The use of model experiments in naval architecture, and Lord Rayleigh's many clever applications of the principle of similarity, are well known. But in extending this reasoning to engineering problems such as aeroplane oscillations, condenser performance and the heating of electrical machines, new questions persistently arose. The most urgent of these have now been threshed out, and the results summed up in a convenient general relation known as the "II theorem," which tells, in any given case, exactly how much can be gotten out of dimensional reasoning, and how to get it. In view of the growing importance of technical physical problems, the value of clear ideas on that subject can hardly be overstated. An abstract and discussion of this work of Dr. Buckingham's appears in the September issue of the *Journal of the American Society of Mechanical Engineers.*

ORGANIZATION AND EQUIPMENT

The scientific staff of the Bureau is organized in eight divisions—weights and measures, heat, electricity, optics, chemistry, metallurgy, structural and miscellaneous materials, and other engineering tests and researches. Cooperation among specialists in the several divisions adds to the efficiency of the experiments any one man is in charge of; for example, he need never be diverted to calibrate for himself his auxiliary instruments; and if he is in a hurry to know what would be the best heat insulator, or what sensitivity

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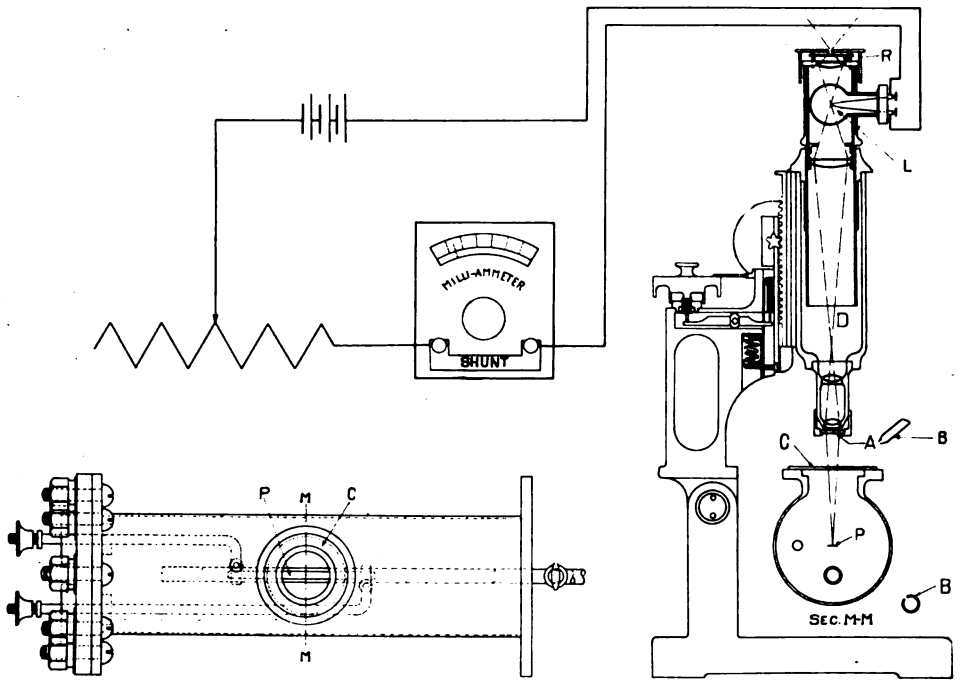
he can expect from his galvanometer, he has only to telephone around to the proper persons. This unique feature is further supplemented by the services of the instrument shop, optical shop, glass blowing shop, etc. The Bureau's equipment at Washington is housed in a group of six permanent buildings and several temporary ones, pleasantly located on the heights between the city proper and the suburb of Chevy Chase. of ten rooms; radium standard; thermocouple used in measuring heat from individual stars; balances good to one part in 100,000,000; Weiss electro-magnet giving 50,000 lines, for magneto-optical research; 2,300,000 lb. Emery testing machine (frontispiece); 400 foot tank and electric car with hydraulic-gear speed-control for testing water-current meters. Certain of these items are impressive in showing the extremely large



THE MICROPYROMETER

New buildings are in course of construction. There is a branch laboratory at Pittsburgh, Pennsylvania.

Among the pieces of equipment which may be seen in a superficial walk through the buildings are: electrical equipment for testing transformers up to 100,000 volts, and for measuring currents of 10,000 amperes; remote control system for regulating frequency, power factor, current and voltage of motor generator sets from any or small magnitudes physicists can nowadays handle with precision in their routine work.

CAMPUS LIFE AT THE BUREAU

The suggestion of campus life one gathers from the attractive quadrangular grouping of the buildings is not at all a misleading one, for the Director of the bureau, S. W. Stratton, is a thoroughly broad man who has not contented himself with developing the routine work, but has personally en-

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couraged such activities as colloquiums, convocations to hear foreign visitors, the Graduate Study Association with its curriculum of lecture courses, the Music Association with its glee club and orchestra, the Athletic Association with its tennis courts, etc.

TECH AND HARVARD MEN THERE

Among the Harvard men at the Bureau are E. Buckingham, best known outside for his earlier work in thermodynamics, and now engaged in the broader field of technical physics above mentioned; W. H. Herchel, who is investigating lubricating oils and testing aeroplane engines, etc.; and R. F. Jackson, engaged in researches bearing on the purity of sugar. Among the Tech men are G. K. Burgess, who on leaving the Institute worked with Le Chatelier in Paris and is now in charge of the metallurgy division; P. V. Wells, who is opening up an interesting field in the optics of heterogeneous media; and F. B. Silsbee, who is returning to the electrical division of the Bureau after a year at Harvard in which he took the doctor's degree.

FURTHER INFORMATION

The invitation of the *Technology Monthly* to prepare this article was eagerly accepted, the writer well remembering the scarcity of information about the Bureau in Boston only a few years ago when he left: but the writing has had to be done at the seashore, with a catboat alluringly tugging at her mooring out beyond, hence brevity and shunning of statistics. For any adequate account, reference must be made to official publications.

The Bureau issues four series of publications: the Scientific Papers, Technologic Papers, Circulars, and Miscellaneous Publications. The bound volumes of Scientific Papers constitute the Bulletin, and are sold now, at the Government Printing Office. The Scientific and Technologic Papers present the original reports of investigations. The Circulars are compilations of information, published whenever the correspondence on a subject gets too voluminous to handle by individual replies. For example, one on The Standardization of Hose Couplings summarizes the co-operative work done to make these fittings interchangeable so that fire engines in one town can help out those in another. Again, a circular on Household Measurements gives information about heating and lighting and purchasing supplies, and how to tell the temperature of fudge, or baby's bath. Some fifty Circulars have been published. The most generally interesting of the Miscellaneous Publications are the Annual Reports of the Director. A classified list of publications will be found in Circular 24; any of them are sent free on request. For advance notices, see the *Journal of the Franklin Institute*. Most of the Scientific Papers appear in a condensed form in the *Journal of the Washington Academy of Sciences* somewhat in advance of their publication by the government.

Obviously the best way to find out about the Bureau is to visit it. The Tech and Harvard men will be glad to show their confrères around, and to put them in touch with the departments in which they may be interested.

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WHY IS THE WRESTLING SQUAD?

By G. H. STEBBINS, M. I. T., '17
Manager of Wrestling

DID you ever by any chance ask yourself "Why is the Wrestling Squad?" Do you ever question yourself upon the why of anything? For instance, why is the "Tech Show," the "Glee Club," or "Precision of Measurements"? They must all have some claim to existence beyond the mere possession of it. The fact alone that a thing has existence does not prove that it has a right to such a condition. I wear a stiff, uncomfortable collar every day, but one has yet to show me a logical reason for its use. In short, we take things too much for granted. If they exist, we recognize the fact and *let it go at that.* We seldom question the purpose of their existence.

In so doing we make a big mistake. Thereby we ignore the possibility that the matter in question may be of benefit to ourselves. I ask, "What do you know about the Wrestling Squad?" You answer that it wrestles, holds meets, and is forever selling tickets. If you are better informed, you may name the captain and the manager. If I ask further, "What good is the Wrestling Squad?" you reply, "I do not know." I query, "What good is it to you?" You answer, "No good." But if I inquire once more, "Have you ever tried to find in it good to yourself?" you must answer, "No."

Yet here are fifty men who make a habit of wrestling at the gym. They wrestle because they find some good in it. And the good cannot be ascribed to the strenuous work involved, the amount of time spent or even the contraction of an occasional cauliflower ear. Wrestling is not child's play. It requires vigorous work and firm nerves. And men do not toil for the mere sake of sweating. These men must find in their "hobby" some direct logical benefit. Again I put my question, "Why is the Wrestling Squad?"

The answer which naturally comes to mind is the physical benefit. It offers relief from the weariness of study. After the monotony of a day's lectures, we are cramped rather than fatigued. Our being needs a limbering process rather than rest. The mat work keeps in balance our two opposing natures—physical and mental. It keeps us from nervous breakdown. Our health is insured by it. In addition, who does not like to possess a good physical development? Many a spindling freshman has seen his slender muscles swell by virtue of faithful wrestling. Many over plump "fatties" have seen their limbs take on firmer curves through the same process. As a means of physical development, wrestling is unsurpassed.

The physical benefit, however, is by no means the entire answer to the question. There is no better guarantee for health than frequent fresh-air walks. This form of exercise takes little time, requires no outlay and is always available. Anyone can do it, for

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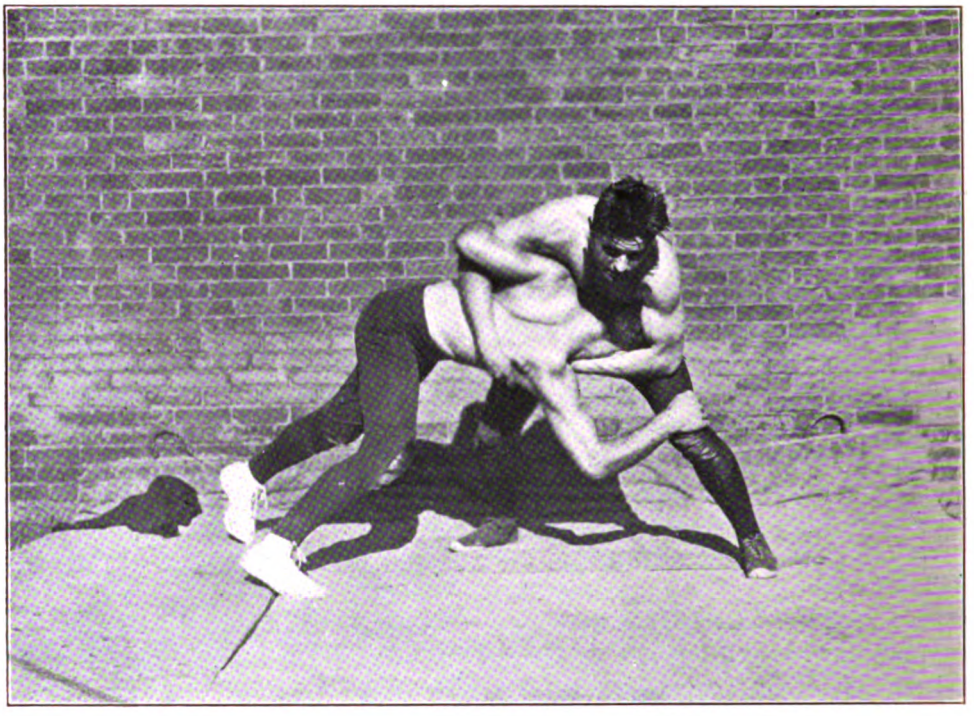

WRESTLING BRINGS OUT THE TRUE CHARACTER OF YOUR OPPONENT

there is not the slightest danger either of injury or over-exertion. Yet the Wrestling Squad leaves the walking to others and in spite of its sore elbows continues to wrestle. It is likewise with physical training. Gymnasium work will produce a set of muscles quite as striking. But the Wrestling Squad is not impressed. Other answers to the question are likewise unsatisfactory. The hope of personal renown alone could not keep fifty men practicing when only seven can make the first team. The possibility of attractive trips would not hold the interest of the whole squad when these same seven alone are taken. I must inquire further in my query, "Why is the Wrestling Squad?"

Before going on let us consider another matter. We all presumably come to the Institute that we may be the more successful in after life. To this end we grind on mathematics, applied mechanics and theoretical chemistry. What else could keep us awake through physics lectures? What else could keep us tackling "Precision" with renewed vigor each year? What else could keep us toiling in chem. lab., week in, week out? The Institute likewise is working toward the same end. It prides itself upon its rigorous training, upon its difficult courses. It points with satisfaction to its well-equipped laboratories. Always our professors have our future in mind. When they spring a stiff "exam.", it is merely that our mentalities be toughened to withstand any shock. If they pile on work, it is only that, if we survive to graduate, we will tackle anything to get relief.

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Through all this training, both parties deal with the individual. It is one of Technology's dearest traditions that she develops individuality. She aims to develop the personality of each student in the direction of his own inclination. Every student is trained to think for himself, solve his own problems and work out his own salvation. When the Institute gets through with a man, he is able to stand upon his own feet and act independently. In the same manner, the student works for himself as an individual. He studies, not for the benefit of Tom Jones or Dick Smith, but that he himself will be the gainer. He works always by himself; always in his own peculiar, self-centered way. Seldom does he consider himself in relation to his fellow-classmates, except to be satisfied that he is holding his own.

But is this training in individuality an assurance of future success? Do you realize that practically all big men have found their prominence in their manner of dealing with other men? And since men must be organized, the successful man must also have the ability to handle an organization. Edison's success is due just as much to his method of dealing with his men and the efficiency of his organization as to his mechanical genius. Many a mechanical genius has given the world nothing, because he never understood the importance of these last two factors. Take other big men in various fields, Schwab, Elliott, Mellen, Wilson,—all know how to handle men—and organizations. The importance of efficient organization is nowhere better illustrated than in the modern base ball club; the great German fighting machine is an example of the same theory. The idea may be summed up in the words of a man who manages a plant employing thousands of men. As I was having a brief talk with him recently, he suddenly exclaimed, "What are you interested in, men or materials? I am interested in men. I do not care whether steam enters an engine at 90 or 250 pounds pressure. I do not care whether an engine makes 50 or 300 revolutions a minute. I leave that to someone else. My work is with men. The successful man of today must be able to handle men."

This point is exactly the one that is slighted by Technology's training. In Freshman Drill alone does the student co-operate with his mates and work for the mutual advantage of all. In Drill alone is the student brought into immediate contact with a group of organized men. Practically every other course at the Institute trains him as an independent individual, working always by himself, always for his own interests. If the Institute does not offer help in this direction, the student must fall back upon his own resources. He must create a course of his own, as it were, in "Men and their Organization."

Let us now return to the Wrestling Squad. It is an organization. It may be loosely connected; it may be haphazard or inefficient, but nevertheless it is an organization. It is, like all organizations, composed of men. Moreover, the men are drawn from far scattered localities and widely varying types. An example is Kelly's Championship Team of 1912-1913. The total distance which the members traveled to reach their respective homes aggregated 21,000 miles. The types varied from the son of a reputed millionaire to those dependent upon their own resources for their education. Here then are the essentials to the

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"FOR HOW CAN A MAN BE DIGNIFIED WHILE STANDING ON HIS HEAD?"

study which I have suggested. Here is the organization, here are the men.

The Wrestling Squad is by no means the only such organization at the Institute. It cannot claim to be organized to the same degree that some of the other activities are. It does, however, excell in some respects. In no other activity are the men brought so close together; in none is the true character of the men revealed so clearly. All athletics bring men closer to each other than do non-athletic activities. And of all athletics, none brings the men so close as does wrestling. For in wrestling you see your teammate as he is. You see him both as a winner and as a loser. You see him in his unguarded moments; you see him under all conceivable unconventional conditions. You see him stripped of all the superfluities and surface veneer which he unconsciously assumes before the public. For how can a man show poise when he is stood upon his head? How can he preserve his dignity when he is gasping for breath?

The man who handles men must be able to understand men's thoughts. He must appreciate their interests and grasp their point of view, even if it is a mistaken one. Not only must he catch the spirit in which men do their work, but also he must sense the motives which prompt men to shirk it. He must be able to put himself in their position and view the world from their standpoint. These characteristics can all be developed by being a member of such an organization as the Wrestling Squad. Especially is this true of the latter because it is a wholesome group of men stripped of all rank and sect. How better can one get in harmony

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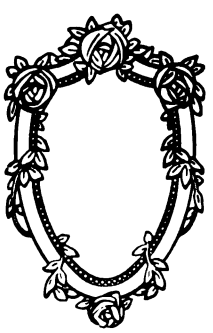
not the trouble. You merely had nothing special in common. You had no mutual cause to share, you had no real interest together. The Wrestling Squad will gladly give you all this. It will get you in with other fellows. It will offer an escape from the state of being always an outsider. It will give you, too, a topic of enthusiastic conversation. It will, in short, accomplish that which makes life truly worth living; it will make you "one of the bunch."
with human nature than by mingling with these men? How better can one get in sympathy with his fellows than by catching their spirit?

The Wrestling Squad as an organization may allow but few men the opportunity of experience in directing such a unit, but it does allow everyone to get in contact with the practical working out of various theories. The manager may evolve a certain pet idea all by himself, but the whole squad gets the benefit of the lessons resulting from the attempted practical application. Other lessons are likewise brought home. An organization is efficient only so long as friction is avoided and the members work together. The member must work not only as an individual, but also in relation to the other members. Self-interest must give way to mutual interest, self-consideration must be superceded by a consideration for the whole. By grasping these truths, the squad can learn the principle of co-operation and self-sacrifice for the good of a common cause.

There remains one thing still which the Wrestling Squad has to offer, i. e., the social benefit. Did you happen to enter the Institute, as so many fellows do, without a single intimate friend? If so, you probably found that acquaintances were made readily enough, but that they were acquaintances and no more. True friends are not so easily made. Have you ever watched with envious eyes as two fellows clap each other on the back and call one another by their first names? Have you ever racked your brains for something to talk about with Smith, and then seen him plunge into hearty conversation upon leaving you to meet Jones? Have you ever wondered if you were different than other fellows that you could not get closer to them? But that is



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FACULTY HONORS

II

CECIL H. PEABODY

Receives Order of the Rising Sun

NEARLY every Tech man for about three decades has, at some time or other during his student days, made the acquaintance of "Thermo." Professor Cecil H. Peabody, the author of "Thermodynamics of the Steam Engine" and "Steam and Entropy Tables" has made a great name for himself in Marine Engineering as well as in his study of the theory of heat, or Thermodynamics. Unlike most men who tackle two such variant fields of activity Professor Peabody has mastered both Marine Engineering and Thermodynamics.

Professor Peabody's name and the Course in Naval Architecture and Marine Engineering seem synonomous to many of us. And Course XIII brings to mind the thought that its main field is to round into shape the very pick of Annapolis men to fit them as constructors in the United States Navy. It is upon this set of men that the destiny of our country may well depend at some future date, and to realize that our own Institute has been chosen by the Government from all other American Colleges for the training of these men is a matter of no little moment.

The year after Cecil H. Peabody graduated from Course II (1877) at the Institute he went to far-off Japan, then a much more mythical land than now, but which is yet revealed to us as most charmingly artistic and quaint. The present line of Japanese Emperors have been on the throne for a longer period than any European country has been in existence as such, and Japanese legends have grown accordingly. It was Commodore Peary of the United States Navy that opened the eyes of the Japanese to modern civilization by carrying a greeting from the President of the United States to the Emperor of Japan about 1850. In this "Land of the Rising Sun" Mr. Peabody became Professor of Mathematics and Engineering at the Imperial Agricultural College. Although he returned to our own shores two years later, his interest in Japan and the Japanese has not diminished. Many of her brightest young men have studied Naval Architecture under him.

As a fitting reward for his long continued interest he has received the highest honor that His Imperial Majesty, the Emperor of Japan could bestow upon him. The Order of the Rising Sun corresponds to such honors as the Iron Cross of Germany and the Legion of Honor of France. Professor Peabody has received the Third Class of the Order.

Prof. Peabody's experiments on the miniature steamship Froude made a profound impression on all who follow ship design. William Froude, a Scotchman, was the originator of the study of Marine Engineering, and it was after him that the "M. I. T. Navy" was named. It was due to the interest and financial backing of Dr. C. G. Weld, of Boston, that the entire experiment was made

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possible. A brief description of the experiment should be of interest.

The United States Revenue Cutter Manning was chosen at the prototype of the Froude. This choice was quite natural since Professor Peabody had made several trials on the Manning itself. The preparation of both model and machinery, as well as the experiments proper, were undertaken by the Department of Naval Architecture and Marine Engineering of the Massachusetts Institute of Technology. The size of the Froude was about one fifth that of the Manning.

The hull was built at Marblehead, Massachusetts, by Stearns and McKay, while the machinery, which was a gasoline engine-generator-moto set, was built by the General Electric Co. at their Lynn works. The motor was very accurately tested by the Department of Electrical Engineering. The gasoline engine-generator-motor set was used so as to get a very accurate measure of the power put into propelling the ship.

The experiments were held during the summer months of 1910 and 1911. The runs were made in the Charles River Basin, in front of what has since been chosen as the New Technology. An interesting feature of the experiments was a long roll of paper turned by a small motor, at a speed which could be regulated, and by the use of several fountain pens with different colored inks a simultaneous record was kept of several factors.

It was found that by projecting the propeller at different distances from the end of the boat different efficiencies were obtained. Some very important discoveries were also made on the efficiency of various forms of propellors and propellor blades.

Professor Peabody became an instructor at the Institute in 1883, he was made Assistant Professor of Steam Engineering in 1884, Associate Professor in 1889, since 1893 being Professor and in charge of the Department of Naval Architecture and Marine Engineering. At the present time he is Chairman of the Faculty.

Besides being the author of "Thermodynamics of the Steam Engine" and of "Steam and Entropy Tables" he is also the author of: Tables of the Properties of Saturated Steam, Valve Gears for Steam Engines, Steam Boilers (with Prof. E. F. Miller), Manual of Steam Engine Indicators, Naval Architecture, Thermodynamics of Steam Turbines, Propellors, and Computations for Marine Engines. The following list of articles also give one an idea of Prof. Peabody's activity: Progressive trials of the "Guardian," Stability of a Battleship under Damaged Conditions, Progressive Speed Trials of the U. S. S. Manning, Some Problems on the Surface of Buoyancy and of Waterlines, Personal Impressions of Model Towing Stations and A Method of Determining Pressure for Steam Turbines.

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FALL TRACK PHOTOS

1, 2 & 3. FALL HANDICAP MEET.

4. Capt. Brown of Tech winning Tech-Harvard Cross Country.

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TECH FIELD DAY

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THE DEVELOPMENT OF TECH SHOW

By CHARLES R. LORD, M. I. T., '16

Editor's Note. This article, in which Mr. Lord tells us of the evolution of Tech Show, is essentially the report which he, as General Manager of "Getting Across," submitted to the Alumni Advisory Committee of Tech Show.

THE first Tech Show had its inception eighteen years ago, due to two causes, the primary one being the need of raising money for Athletics and the other a realization on the part of those responsible for the development of the Show, of the lack of fellowship and social life in those days in a school of the Institute's character, and a desire to give the students an opportunity to become better acquainted and have a bit of the college atmosphere. With these causes for its development, the Show has grown tremendously until now it is a large and complex organization occupying an important place in the undergraduate life.

The birth of the Show was not due to any undergraduate organization at the Institute but to a few energetic fellows who realized the circumstances of the Athletic Association and were determined to help better its condition. These men were the self-appointed managers of the original Show, and as the first performance was a success both financially and artistically, it was natural that the Show should be continued year after year. Just what the first Show was like, I cannot say, but I imagine it was similar to "Ich Kabibble" and "Niemand zu Hause," the musical entertainments that sprang up two years ago to assist in raising money for Athletics, and which met with such success because they cost practically nothing to stage and quickly turned over about five hundred dollars apiece—why they continue to be in favor I don't know, unless it is that they are very informal affairs, and when one attends he is not in a critical mood.

I have mentioned briefly the birth of the Show, and now comes the largest subject, its growth and development. From the start the Show was popular, and as time went on grew more so, and gradually more was done to produce it as a wholly undergraduate affair. Only three years ago a student orchestra was installed in place of the professional band, and this movement alone added twenty-five active members to the Show's already large number. Student light operators have recently been introduced, so that now there is not a department in the Show from the writing of the libretto to the handling of properties, that is not carried out by students, except for the coaching and scenery shifting.

During the last five years, the Show has grown very materially both in numbers interested, and in cost of production, — the latter without entire justication. In fact the Show grew so rapidly with the addition of men in the cast, the chorus, the management, the

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orchestra, etc., that the managers during that growing period were chiefly concerned with their new additions. They overlooked somewhat the fact that if they added expense in one direction they must cut it down somewhere else in order that the same profit that had, previous to 1910, been turned over to Athletics every year, might be made, for the gross receipts continued about the same.

For the past few years the number that tried out for the various competitions connected with the Show has been fairly constant. Every year about three hundred men attempt to better the Show with their services. In the past year these men were divided as follows: one hundred came out for management, music-writing, lyrics, making posters, etc., while two hundred tried out for the cast, chorus and orchestra. These seem to be about all the men who think they have the time or the talent for the Show, but as the watchword of the Show has always been, "The best man for the place," if more ever desire to compete, the quality of the Show should be raised.

Of these men, in the neighborhood of one hundred are finally selected as the successful candidates for the various positions in the management, cast, etc.

With the growth of the Show in numbers interested, came the desire for a real musical comedy similar to a Broadway Show. Consequently, within the last few years, a professional dancing teacher and orchestra director were added to the already heavy expenses of the stage department. The 1910 Show was the last to have the services of a reasonable salaried coach, and ever since that time up to the present, a coach whose reputation could not have been better but whose decided ambition it was to die a millionaire, has handled that end of the Show. Last year it was found that the coaching department was receiving three times as much as it did back around 1905 and 1906, when the most successful Shows were given.

While expenses both in coaching and transportation charges for the larger number connected with the Show were increasing by leaps and bounds, everything in the stage department seemed to come higher year by year. Costumes, scenery, lighting—all had to improve with the new standards set for the Show. Then came the change in theatres, and this did its part to cut down the net profit, although it increased the popularity and social standing of the Show considerably. Through all the years of its existence, the Show had been a mainstay of Junior Week among the undergraduates, but not until the evening performance at the Boston Opera House was given, a few years ago, were the Alumni really encouraged to get together with the different class reunions and spend a pleasant evening socially, and at the same time help the undergraduate activities of the Institute. The Opera House performances raised the receipts, but the expenses were heavy and more than counterbalanced the gain. However, these performances have done what nothing else could do; they have gradually been increasing the interest of outsiders,—Bostonians who are not Institute products. This has been a noticeable and encouraging occurrence during the short time that the Show has been given there. When the time comes that the Opera House seats are as much in demand as were the

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seats at the smaller theatres (the Colonial and Shubert) ten years ago, when the number of seats sold to one person had to be limited, the Show will be in a position to support Athletics and establish a Scholarship Fund as well!

With this increase in size and betterment of production, an approved system for the appointment of the Managers was installed. At first the Show had been perpetuated in a perfectly natural way, the men graduating filling their places with the fellows whom they considered best qualified to carry on the work. Under this system the democratic spirit of the Show was felt to be at stake. This was easily remedied. The Show was given under the auspices of the Student Body, therefore the Student Body should say who should manage the Show, and they should audit the Show's accounts. Consequently, the Show management acknowledged allegiance to the official representative of the undergraduate body, the Institute Committee.

There had been an informal Advisory Committee consisting of a few former Show men who had given their advice from time to time to the Show managers, and this had proved such a help that it was decided to put it on a formal basis. Consequently, the Institute Committee asked the Alumni Council as representing the Alumni to appoint three men who should act as advisors. This committee considers all appointments to the management and makes recommendations regarding them to the Institute Committee. The Advisors likewise audit the books and give their experience and advice to those new in the business world.

Every show has a definite procedure of its management. The retiring General Manager recommends to the Advisory Committee the managers for the succeeding year, stating their characteristics and capabilities. The committee approves and recommends appointments to the Institute Committee. The remaining managers automatically drop out of the management. The General Manager recommends the different assistants as candidates for managers of the departments and the same procedure is carried out. The retiring General Manager with his board wind up the entire business of that Show and turn the profits over to the Institute Committee.

The next management is entirely independent and competition is started again for the lower positions on the management. An amount of $250 is turned over to each succeeding management for working capital.

Looking back over the Shows for the past six years it is seen that in 1910 the last show of recent years was presented which did not allow its production expenses to run away with its income. In that year something around eleven hundred was realized. The following is a short resumé of these latter Shows with their receipts, expenditures, profits and per cent of profit to receipts:

		Receipts	Expense	Profit	Per cent Profit
1910	Queen of the Cannibal Isles	$7,346	$6,227	$1,120	15.3
1911	Frenzied French	6,562	5,839	723	11.0
1912	Castles in Spain	8,094	7,793	300	3.7
1913	Money in Sight	8,000	7,200	800	10.0
1914	A Royal Johnnie	8,025	7,400	608	7.6
1915	Getting Across	8,250	6,340	1.906	23.1

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Glancing over these receipts and profits it is quickly seen that although receipts have increased about a thousand dollars, the profits have fallen an average of five hundred. This means that fifteen hundred dollars extra has been expended in every Show after 1910 in its production.

It was quite natural then, this year, for the Show to attempt to get back to its original purpose. It seemed as though that instead of looking around to spend money it would be more to the point to see where it could be saved. At the very start of the school year a budget was compiled, using the bills of the previous year as a basis to work upon, and each department head was assigned the portion that concerned him. It is one thing to make out a budget and another thing to adhere to it, but this was done in very nearly every item, the budget of over $6,000 being over expended by only $250, most of which was used up in theatre rental and costuming which was not anticipated.

The treasurer was instructed to pay all bills as soon as they had been approved by both the person contracting for the expense and the General Manager, and he also made it his business to see that as soon as any money was expended the manager causing it filed a numbered voucher which had the items of expense upon it and was likewise approved by the General Manager.

This year it was decided that as it was a poor year for Shows in general it would not be advisable to attempt the Providence trip which had proved a loss the preceding year, and consequently only four performances were given, Northampton, Malden and two in Boston.

Our program advertising which is usually the greatest source of profit fell off by $500, but this is probably accounted for by reason of poor business, and not through lack of effort on the Business Manager's part. The ticket receipts were also less by $150.

More men than ever stuck with the various competitions this year and at the end of the Show there were over one hundred taking active part in its production. Some years when the profit has been small the final dinner has been omitted, but this year it was felt advisable to wind up with a good time in order to prepare a good beginning for next year.

It was the Management's aim from the beginning to collect advertising and other moneys due the Show and to pay the bills promptly. This was carried out and three weeks after the last performance the bills were all paid and $1,500 turned out to the Institute Committee to do with as they saw fit.

All profits over that $1,500, which will be in the neighborhood of $500, was reserved by the Show to establish the Tech Show Fund to be held in trust by the Alumni Council until the Walker Memorial Building across the river is completed. Then the Alumni Advisory Council will use it to furnish and equip the Tech Show office.

In summing up the evolution of the Show, it will be seen that at first it started more or less like a vaudeville for the purpose of raising funds for athletics. As it grew in size and popularity it reached a position where it was an annual occurrence for the Show to turn over $1,000 or more to Athletics. Still further in the Show's development came the time when the managers lost sight of the original purpose of the Show and attempted to get a little too

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much art in the production, that is, to spend more money than they should have. This attempt lasted, as may be seen by the profits, for a period of about five years. And now the ball is started rolling in the other direction, as is seen by the profits of this year's Show, and athletics are once more assured of a substantial income. We hope that the show did not suffer through the economies of the past year, for it was entirely through economy that the profit was realized.

THE INDUSTRIAL APPRENTICE-SCHOOL SYSTEM

By RALPH H. HALL, M. I. T., '07

THE present lack of skilled mechanics is caused by a series of conditions, the more important being the decline of the old apprenticeship system, specialization or division of labor and automatic machinery. Contributing to these are many modern influences. Today the boy cannot watch at the open door and become interested in mechanical work—in fact the tendency seems to be to look down upon a trade that soils the hands. And yet only seven out of every hundred grammar school graduates enter high school, the result being that a great majority are eventually forced into the industries.

Specialization being everywhere prevalent, the boy goes into the shop and learns to do one operation and rarely knows the finished product. To become proficient, he must go from shop to shop to acquire the details of the trade and therefore is not of full value to his employers. Thus labor on the whole is less skillful, while modern methods and automatic machinery require more skill and knowledge to be adequately handled. Under these conditions it develops on the foreman to teach the workman, for which instruction the foreman in many cases is not fitted, and which the concern does not want him to do. In addition, those who have mastered their trade in the majority of cases have been advanced in position. Therefore the American industries, that they may attain the supremacy they should hold, must have an ever increasing supply of skilled mechanics.

Many of the industries realizing this have for some time been working to establish a means of supplying this demand and after much consideration and trial have evolved a method, which for want of a more definite title, is styled the Industrial Apprentice-School Sys-

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tem. It is a general plan which many concerns have adopted, with the necessary changes, to suit their conditions. It purposes, in addition to training apprentices for skilled mechanics, to give them a foundation upon which they may keep building and thus advancing as far as ability permits, for while the percentage of foremen and executives is small, there is always an opportunity for those that have the ability and training to reach these positions. In order to do this thoroughly, schooling is a necessity. Thus the school or mind training is a very important part of the system.

In the smaller shops where the expense would be too great, and for other considerations, arrangements are made whereby the apprentices attend for five hours a week a public technical school, where they are instructed concerning the theory pertaining to their trade.

Perhaps a brief description of one of the regular apprenticeship schools would give a clearer idea of the work and results sought for. The Yale and Towne Manufacturing Co., after trying various systems for forty years, started their present school in 1908 and since then have constantly improved and built it up to the present successful condition.

In order to turn out good product, it is necessary to have the proper material. It is necessary to discover the native abilities of the boys, for a boy that is naturally a salesman makes, at best, a poor mechanic. This is well represented by the old expression "a round peg in a square hole." The first step then is to determine the indications of the abilities of the applicants, and in this case by examination.

The apprenticeship school at the Stamford, Connecticut, plant is open to young men who are sixteen years of age and upwards, who are sound of body and can pass the entrance examination. This consists chiefly of arithmetic, spelling and questions of a general nature equivalent to work of the eighth grade. The applicant after passing his examination is put to work in the training room, a series of rooms apart from the toolroom, where he is closely watched by competent instructors to see if he has the necessary ability to become a mechanic. If at the end of three months he has not shown this ability he is so informed and advised of any abilities manifested, and allowed to withdraw. On the other hand if he has shown the necessary qualities he is allowed to continue his four years of training.

The younger apprentices are coached in their work by the ones older in service, who in turn are responsible to the instructor. The result is that the young men are impressed with the necessity of getting every point thoroughly as they go over the work. This also gives everyone the opportunity to use and improve his executive ability as he goes along. The work consists of making the tools used in the manufacture of the company's product; and as there are over six thousand distinct tools, the field covered is very broad.

The apprentice's interest is held as he carries a job right through, that is, it is his job from start to finish. He has made something. Not only is he interested but he sees for himself the dependence of one operation upon another for the accuracy of the completed tool. So from the start he is made to realize the importance of being accurate by his own work, whereas if he were running each machine for a stated

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period, doing but one or two operations, he would have to gain this knowledge from someone else, and his interest would be lagging most of the time. As all of his work has to be passed by the regular inspector the apprentice is taught on all sides that accuracy and practicability are the keynotes. After attaining these to the proper degree he is expected to maintain the proper production, but never at the expense of accuracy. This is accomplished by keeping a record of all the tools made, showing by comparison with previous work the apprentice's ability or deficiency regarding production. From the day he starts he is made to realize that he is learning under actual working conditions and that he is advanced in his work as fast as he is capable of handling it.

After the third year the apprentice goes to the toolroom where he "rubs elbows" with the journeymen and thus still further has the "corners rubbed off," so to speak. Here also he is allowed to specialize in work for which he has evinced particular aptitude.

In geometry class the proposition regarding the perpendicular and oblique line was being demonstrated with difficulty by one of the apprentices, and the instructor to draw him out asked what the oblique line was for. The apprentice said: "To lean the perpendicular on." While the schooling is hardly represented by the oblique line, it is as necessary to the apprentice's education as the line is to the proposition. The skilled mechanic must be familiar with the theory to do his best with the practice, therefore the student to be advanced as he should must have the head trained as well as the hands Thus they are required to attend the company's school for five hours per week, forty weeks during the year, for the entire four years, and are paid for this at their regular rate. Here the instruction is of a practical nature to go with their work so that they realize that one belongs with the other.

In mathematics the work consists of mensuration, sufficient algebra to work ordinary equations and formulae, plane geometry, trigonometry and elementary mechanics. All the examples and problems are taken so far as possible from actual working conditions pertaining to the shop. Particular emphasis is laid on this point that the apprentice may understand how essential his mathematics are to the rest of his training.

The mechanical drawing covers geometrical figures, projection, surface development, gears and cams, sufficient to enable the student to make a readable working drawing. Isometric freehand drawing is also taught so that the apprentices are able to make and dimension a sketch of a machine part or similar object.

All through the schooling fifteen minute lectures are given on subjects that are of interest to them in becoming good mechanics and good citizens. The library in connection with the works, being open to all, furnishes still further means for broadening and developing the mind. So the school besides giving training in technical subjects serves to hold the interest, and broaden the mind, making better mechanics and better men. It has been found by experience that the time taken for school does not interfere with the production, there being as much work turned out when school is going on as during the vacations.

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The apprentice during the four year contract has his pay advanced every six months, after making up any absences, and upon graduation, if his work has been satisfactory, receives a bonus of $100. He is also offered a position, his rate being determined by his record.

That the system is successful, i. e., accomplishes its purpose, is attested by the fact that at present there are executives, draftsmen, patternmakers and many toolmakers graduated from the course who are giving an excellent account of themselves. The company feels that it is repaid, as it has the pick of the trained young men thoroughly imbued with the company's work and policies. That it is successful from the apprentices' viewpoint is shown by the fact that applications are received from many places outside the state. Its strongest recommendation, however, is that there have been but three desertions from the school in seven years, and an average attendance of seventy-five is maintained. This shows that they understand before they acquire their trade, the value of the course.

As this school is but one instance, perhaps it is well to state than many concerns throughout the country are conducting Apprenticeship Schools. The Fore River Ship Building Corporation, the General Electric Co., the Packard Motor Car Co., the National Cash Register Co. and the Pennsylvania Railroad Co. are a few of the many prominent companies. When such representative concerns are doing their utmost in this direction, it shows the pressing need, and the efforts to meet it, of producing skilled mechanics.

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MINING DISTRICTS OF NORTHERN ONTARIO

By ROBERT LIVERMORE, M. I. T., '03
Manager of the Kerr Lake Mining Co., Cobalt, Ontario

Editor's Note. In the article by the same title in the November issue of The Technology Monthly and Harvard Engineering Journal Mr, Livermore described mining in the silver fields. In this article the gold fields of this same part of Canada are described.

THE discovery of Cobalt stimulated the search for precious metals greatly. Individual prospectors swarmed into the "bush" by every practicable route, and the skepticism toward Ontario silver mines once dispelled, many exploration companies sent men into the field. This active search opened up a few districts such as Gowganda and Elk Lake, and scattered discoveries elsewhere, as well as extended the Cobalt district to South Lorrain and Casey townships. All of these localities are or have been producers, but none have approached in importance the original discoveries.

During the next few years, while Cobalt was arriving at prosperity, the Government had been extending its railway steadily northward toward its ultimate goal, the clay belt on the Hudson Bay slope of the height of land. The railway gave a convenient base for the prospector, over which he could transport his canoe and supplies, sally forth by river and lake, and his claims staked, return in quick time to the centers of finance at Cobalt and Toronto, where his tales of new finds, backed by specimens of ore, found ready credence.

The speed with which the rich surface deposits of Cobalt had made fortunes over night, the ease with which money, either real or on paper, was raised in the then flush times of Canadian prosperity, all made this the land of the prospectors' paradise; for often a man had only to prove that he had located rock outcrops known to be of the favorable formation, when he could sell for a good round sum, without having done more labor than to stake his claim, and perhaps to strip off the moss from the rocks.

In 1909, the discovery of gold in the quite remarkable outcrops near Porcupine Lake set the north country on fire with excitement. If, it was reasoned, the Cobalt ores, which are only silver, made such fortunes, what would gold do for the lucky finder? What are now the Dome and Hollinger Mines were first staked. Within a few weeks after their importance became known, a feverish rush was on, and at least three townships around them were staked in short order.

The Porcupine District lies about thirty miles west of the main line of the railway, some hundred miles northwest of Cobalt, and only one hundred and thirty miles to the south of Hudson, or rather James, Bay. At first it was reached by canoe through the Frederickhouse and Nighthawk Lakes, and the Porcupine River, but a stage road was soon run which made transportation more possible, and in 1911 a branch of the railroad was put through to the district. Towns sprang up over night. There were townsites laid out every mile or so, and lots sold at

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bonanza prices in all of them. Hotels, stores and dwellings were built, and stockbrokers' offices abounded on every corner. The well intended Canadian law, forbidding the sale of liquor within five miles of a mining center, prevented the openly conducted saloon so familiar to our western mining towns, but many a fiery bottle changed hands nevertheless. Prospectors, veteran or "tenderfoot," pack on back in summer, with dog team in winter, came and went, bound for new strikes, or bringing in tales of their discoveries; mining men, promoters, laborers, all the rank and file of those who follow the opening of a new district, thronged the streets and trails. Claims were bought and sold for large sums, often without the new owners having seen them. As a visiting engineer put it, "Gold in place is held at fifty thousand dollars a speck!"

Porcupine suffered from unmerited troubles too, so much so, that for a year or two it was in danger of becoming known as a "hard luck camp." In the summer of 1911 a fire wiped out the newly built mill of the Hollinger Company, and later in the same summer the great forest fire of that year, driven before a southwest hurricane, totally destroyed the plants of the entire district as well as the largest town, driving the people to the lakes, where many of them died from suffocation or drowning. Over 70 lives are known to have been lost, and no doubt many a poor prospector, unable to reach a place of refuge, perished in the bush, unknown. Hardly had the place begun to recover from this horror, when a disastrous strike, engineered by the ubiquitous Western Federation of Miners, partly closed the mines and again greatly retarded its development.

The owners of properties in Porcupine were soon to find that the development of a comparatively low grade gold deposit was a far different matter from that of rich silver ore carrying thousands of ounces to the ton, and the trials which beset them would have put a quietus on a camp of any less real promise. Although some very spectacular showings were found, high grade ore which could be shipped and realized upon without further effort was soon found to be only an occasional product. Mills were erected which were hardly suitable even for the freer milling surface ores, and which were entirely unsuited to the more complicated ore which formed the bulk of the deposits. The "wild-catting," the over-capitalization and under-financing, all of which seem to be inevitable in newly discovered camps, and the consequent failure and disrepute which such failures brought upon the district as a whole, all hurt its development.

Attention was attracted to the first discoveries of Porcupine by the immense outcrops of quartz in rounded masses, called "domes," whence the mine of that name took its title. None of the veins are true fissures in the western sense of the word, but are more properly fillings or replacements in pre-existing shear zones of the country rock, and are extremely irregular in their nature. The quartz at times assumes the appearance of a fissure vein, but is apt to "pinch," and to disappear. Often, in such cases, a crosscut driven to one side will pick up the ore body in another shear plane. Faults are numerous, and often have displaced the veins for many feet. The irregularity of the veins would react greatly on the confidence held in their permanence, were it not for the fact

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that they occupy well recognized and regular shear zones of established great depth, and though locally erratic, are continuous with and characteristic to these shear zones. The principal zone lies in the westerly end of the district, running in a northeast to southwest direction for several miles. In this belt are situated all the producing mines, with the exception of the Dome.

All the ore-bearing rocks of Porcupine are, like all the known deposits of Northern Ontario, of pre-Cambrian age. The Cobalt series is represented, but is not usually the ore-bearing formation. An intermediate series called the Temiskaming, also present at Cobalt, but not there ore-bearing, is here productive, but the principal formation, which contains the deposits of the greatest economic importance, is made up of the older Keewatin rocks. These are here metamorphosed greenstones, basalt, and other volcanic rocks, all much altered in the ore zones to schist. While in Cobalt the Huronian slates and conglomerate are sought for ore, here the schist is the best indication, for in such zones fracturing and fissuring has been most complete. The values in the ore bodies may appear as free gold in the quartz, or as invisible particles of gold in combination with other minerals, the commonest of which is pyrite. Gold values also extend into the wall rocks, especially where pyrite abounds.

The ores of Porcupine are not high grade. Twenty dollars a ton is exceptionally good, and the average is much less than that. The Dome Mine, for instance, treats at a profit ore assaying less than five dollars per ton, and the Hollinger Mine, the premier mine of the camp, is now treating ore of less than twelve dollars. The large tonnage handled makes possible a very low working cost and consequent good profit. The most striking and satisfactory feature of the Porcupine mines is that the limit of their ore does not seem to have been yet reached at depth. Developments so far have shown that the deposits are of deep-seated origin and liable to extend to good depths without much change of valuable contents.

THE DOME MINE

As in Cobalt, actual mining is simple. All properties are worked in the usual way, through shafts with levels

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at regular intervals, and by overhead shrinkage stopes. Little sorting is necessary or even feasible, as it is not easy to distinguish ore from waste. Mining is on a much larger scale than in Cobalt, since the larger tonnages mined and milled make more elaborate methods of handling ore to the surface necessary. The Hollinger has a central haulage level to which most of the ore is passed and trammed by electric train to the main shaft. The ordinary stull and lagging timbering was used in the upper levels but in the newer levels the method of leaving pillars of solid rock over the levels is being used. The Dome Mine, on account of the peculiar nature of its largest ore body, uses a sort of "glory hole" method of mining, by quarrying from the surface down, and drawing off through underground levels. Mules are used for underground tramming. On account of the width of the ore body the rib pillar system of mining, modeled after the Homestake method, has been adopted in the lower levels.

The mills of the camp, after long experimentation, have reached great efficiency both in quantity of ore treated and in good extraction. The milling practice varies to some extent, but the leading principle of all practice is cyanidation, either after preliminary amalgamation and concentration, or without. The Dome Mill has 80 stamps crushing through a coarse-mesh screen and sending the product through tube mills for finer grinding. This product is amalgamated, the pulp classified, and the various products cyanided in Pachuca tanks, with some later grinding and amalgamation of concentrated products.

The Hollinger Mill, which treats also the neighboring Acme Mine ore, has 100 stamps (stamping the ore in cyanide solution), tube mills for regrinding, Deister concentrating tables and a continuous decantation cyanide process for sands. Concentrates are stacked for special treatment. The Hollinger-Acme Mill treats 1,400 tons of ore per day, the Dome Mill 900. With some variants of these processes, such as the substitution of Hardinge Ball Mills for stamps, and different types of filters used, the other mills are based on the same principles.

Power is obtained from a custom company having two power plants on the Mattagami River. As this supply is at present inadequate for the rapidly increasing use, most of the mines have auxiliary steam-driven compressor plants.

Porcupine overshadowed the other gold districts of Ontario as much as Cobalt did the silver districts till within a year or so, but during the last two years several districts of interest have been opened, and at least one of these, Kirkland Lake, shows signs of becoming a steady producer of gold. Among the more important discoveries are the districts of West Shining Tree, Swastika Sesikinika, and Larder Lake. Besides these there are numerous scattered prospects showing gold in greater or less quantity all through the country, but not as yet dignified with the name of "camp."

In the first mentioned district there are several rather promising occurrences of gold in wide, but extremely irregular quartz veins in Keewatin rock. A good deal of work has been done, but inaccessibility (for the district lies some fifty miles from the nearest rail) has undoubtedly retarded development. It has not reached the producing stage.

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Swastika lies on the railroad fifty miles north of Cobalt. Its deposits consist of wide quartz veins in which the values are very irregularly distributed. Although two mills have been built and some bullion produced, these properties have not been profitable and are at present shut down.

Six miles east of Swastika is the Kirkland Lake district, which has come into considerable prominence through the development of its one producing mine, called the Tough-Oakes. This mine has the distinction of being the one gold mine of the north which, for a time at least, paid its way from "grass roots." A narrow but rich vein containing free gold was opened by inclined shaft for two hundred feet, which produced enough high grade shipping ore to pay the costs of all development and construction, including plant, buildings and a small stamp mill. The ground was first staked in 1906 during a rush to the Larder Lake district, further east, but little work was done on the claims, and the locations were allowed to lapse. In 1912 gold was discovered in the Tough-Oakes vein, named from the prospectors who found it, and the subsequent developments renewed interest in the locality. Many claims were staked, and numerous veins were opened up. To date, though several properties have great promise, the original discovery has remained the most important and only producing property. Development of the district has been held back by the usual financial mixups, by the disinclination of responsible companies to step in, owing to onerous terms asked by owners, and, of late, by the disturbed conditions due to the war.

The veins of Kirkland Lake are narrow and unpromising in appearance. However, many of them contain quite remarkable gold values, and often the wall rocks are impregnated with gold sufficient to make rock of milling grade for a good width. The only mill in the district is the new 200 ton all-cyanide plant of the Tough-Oakes. This has been so recently put in commission that no data can be given regarding its efficiency. The rocks of this region are of the Temiskaming series, of conglomerate and graywacké, altered and schisted by a subsequent intrusion of porphyry. The veins occur in both conglomerate and porphyry and are seemingly unaffected in value by the change of formation. The older Keewatin rocks do not appear here, so that as yet their influence on the veins is not known. Several interesting minerals occur with gold. Telluride of lead, altaite, is frequent, and molybdenite is common. Some specimens of calaverite, telluride of gold, have been found. The district is as yet very new, but when development and steady production have become more in evidence seems destined to become of importance to the gold mining industry.

Of the other districts mentioned above, Sesekinika lies directly on the railway a few miles to the north of Swastika. This district has been little developed as yet. So far as known the deposits consist of narrow quartz veins in Keewatin rocks which contain occasional spots of free gold and tellurides. It is chiefly interesting as showing how discoveries can be made in much traveled districts, since the finds all lie within sight of the passing trains.

Larder Lake was discovered in 1906, and a large amount of work was done. Although machinery and mills have been brought in, and some bullion produced, this district is not at the pres-

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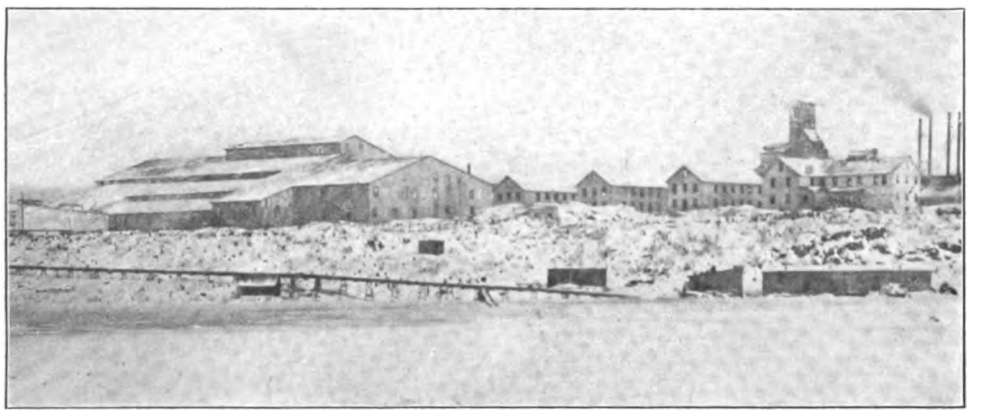
ent time on a producing basis. The country is highly mineralized and it is quite possible that developments at greater depths may prove its worth. Those deposits which the writer has seen consist of irregular bands of sulphide ore in conjunction with large porphyritic dykes cutting through Keewatin country rock. The sulphides, which are of iron and copper, are much more in evidence than is usual in other districts. The gold values seem to be largely confined to these sulphide bands. Magnetite is also quite a common mineral, and sometimes carries free gold.

It may be said that an industry is on a most substantial basis, which like this of Northern Ontario, can in a few years place a whole province among the largest producers of the world's silver, and cause it to make rapid strides towards becoming one of the great gold producing centers. Even in these times of financial depression when the nation is at war, no great setback has been had to the steady progress of the mines.

Hopes for the future are bright, as the territory is vast, and except where the water courses and the few railroads have made easy prospecting possible, has been but little explored in a systematic way. It is probably true that the obvious finds have all been made, and that future discoveries, on account of the difficulties of travel and search through a bush and muskeg covered country remote from the natural routes of travel, will be slow. Possibly another Cobalt or Porcupine will never be found, but no one can help but believe that many important additions will be made to the producing mines of the northern part of the Province.



THE HOLLINGER MINES

The foregoing is a very general and necessarily limited description of the more important mining centers of Northern Ontario. Like the would-be "expert" reporting on a mining property, whose only statement under the head of "Geology" was, "The Geology of this property is very satisfactory," he realizes that much detail is omitted which should in a more comprehensive treatment be fully brought out.

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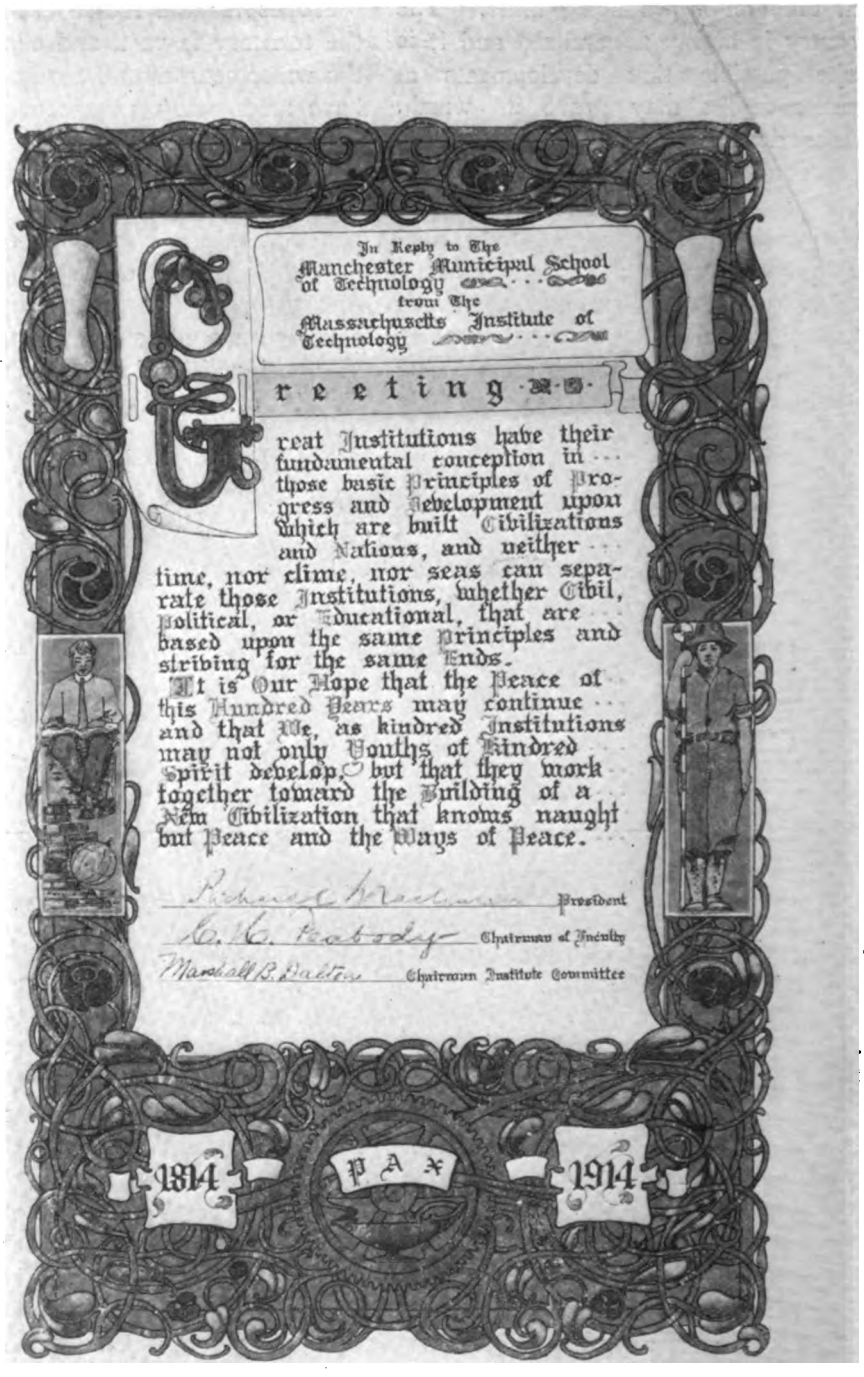

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THE MANCHESTER PARCHMENT

By O. R. FREEMAN, M. I. T., '15

FOR two great nations with over three thousand miles of common border and with conflicting commercial programs to remain at peace for a century is unusual. The Great War has but recently impressed this fact on our minds. From the Atlantic to the Pacific, and from the Pacific to the Arctic there is not a single fortification. Time and again Great Britain and the United States have settled disputes, that many another country would have gone to war for, by arbitration. It was the feeling of something fundamentally common in similar education that started a movement in the "Tech" of England with the results of which most of us are more or less familiar.

Last spring the Institute received from the Manchester Municipal School of Technology in Manchester, England, a congratulatory message on the hundred years of peace that had existed between their country and ours during the period since the treaty of Ghent at the close of the war of 1812, that treaty having been signed in December, 1814. At the time a letter of acceptance and thanks was sent by the Institute Committee, in whose hands President Maclaurin had placed the document.

A committee was then appointed by the Institute Committee to formulate and execute a formal reply, the same to be done on parchment. John Alden Root, '14, and Osborn Ricker Freeman, '15, were selected as the committee and started immediately on the work. Eastman A. Weaver, '15, was given the responsibility of the delivery of this work of art.

The first question settled was the matter of presentation. Illuminated work, as much as possible after the early English work, yet not savoring of direct copying of ancient motifs, was decided upon. The text was transcribed and approved by the Institute Committee. The space to be occupied by the text practically determined the massing of the sheet.

The next question to be settled was the degree of elaborateness to which the design should be carried. After many attempts to determine the status of the Manchester institution in terms of American college rating, that the reply might represent to some degree the importance of the Institution to receive the document, it was finally decided that the work should rather represent what we considered the standard of our institution than that of the one across the water.

Then followed a search of the Boston Public Library to determine the colors and ideas used in illuminated work. pure red, blue, green and gold were decided upon, and sketching began. But school then came to a close and the committee of two were forced to separate. Each had, however, the ideas of the other upon the matter, and felt free to do as much on the proposition during the summer as they desired.

The third great question to be decided was in what style the whole work should be done, as in all the arts, the styles of

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the different schools vary greatly. The fact that the work was going to England was probably the deciding factor in favor of an entire English presentation, both in lettering and design, rather than, say, the Italian or German school.

This meant a study of the English school of illuminated text work, and for this purpose the work of the modern English illustrator and designer, Walter Crane, and the designs of William Morris, the founder of the modern handicraft idea, were consulted.

Then came the final assembling of all ideas and research into that form which should represent both institutions, their ideals and their native aspects. The rose, as a symbol of England, was chosen as the motif for the scroll work. The cogged wheel, though primarily a symbol of mechanics, was used to represent the technical nature of the two institutions. But the heart of the whole thing, the origin of the whole design, actually and in theory, was learning, education, that which brought into existence not only the two institutions, but, through serving as the means by which civilization has spread, brought about the exchange of greetings. The lamp of learning, therefore, occupies the centre of the main design and from its flame the whole remainder of the fabric is formed. The Institute is represented in its dual capacity of turning out the student as well as the engineer by the two panel figures, the one of the student with his books and the other the engineer in his field regalia. The object of the document itself is represented in the word "Peace" and the two dates marking the beginning and the close of the hundred years as they are written on the scrolls at the bottom of the sheet. But illuminating was a creation of the patient, toiling monks of the mediaeval monasteries, and so to pay homage to the originators of the art the word "Peace" has been inscribed in Latin, the language of the monastary.

So much for the design itself. As to the text, something more than a mere thank-you was desired, something that would carry with it an idea of hope in this dark hour of the world's history, something that would convey an idea of the final triumph of peace. Nothing seemed more symbolic of the idea of the continuity of peace than the use of the idea of an underlying Principle governing all things, for principles are unerring and everlasting, being things not of this world, but only sensed by mortals as they pierce here and there the veil of human ignorance and come into contact with the verities of being. So the opening words of the text itself, "Great institutions have their fundamental conception in those basic Principles of Progress and Development upon which are built civilization and nations—" convey the idea that no will or idea of mere man has brought into existence these schools, but rather, that they are the inevitable working-out of the Infinite plan of Progress and are a part of the fabric of world development. From this the next statement logically follows, that "neither Time, nor Clime, nor Seas can separate those institutions, whether Civil, Political or Educational, that are based upon the same Principles and striving for the same ends."

Then, approaching the ground of the object of the work, we wish the peace of this hundred years to continue, and, to tie this statement with the introductory idea, that of the unity of education, we express the hope that these kindred institutions "may not only youths of kindred spirit develop, but that they work to-

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gether toward the building of a new Civilization that knows naught but Peace, and the Ways of Peace." In other words, we have tried to make the text convey a national ideal and express a world hope, as well as convey the purely local response to the message so thoughtfully sent to us.

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All manuscripts submitted for publication in the TECHNOLOGY MONTHLY AND HARVARD ENGINEERING JOURNAL should be accompanied by the writer's full name and address. Manuscripts not accepted for publication will be returned only if the author so requests. Photographs, drawings, etc., will be returned to the contributor immediately after publication.

Forms close the 28th of the month immediately preceding date of publication. Material specially arranged for may be received up to the fifth day following.

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EDITORIAL

THE GENERAL UTILITY OF A TECH EDUCATION

IT can by no means be said that all graduates or all near-graduates of the Institute follow engineering or science as their life's work. A large number follow branches of industry which do not come within the courses which they studied at the Institute.

Our Faculty intend that the courses we follow shall primarily fit us for straight thinking. While we are particularly taught to think in terms of our future profession, the ability to think in terms of one profession does not prevent us from doing the same thing in terms of another. Our courses are noted more for scientific or engineering thoroughness than perfection in one particular "trade."

It is this thoroughness that enables us to grasp opportunity in another branch of engineering, and which serves us in any emergency we may meet.

This idea is expressed in the following words by an alumnus: "The technical, careful and inquisitive training received at the Institute have made themselves manifest in a number of cases where accurate decisions were necessary. The steam tables of Thermodynamics have long since been forgotten, but if occasion required, intelligent access to them could be had, which after all is the value of an education." This alumnus was graduated from Course II. An exceptional opportunity came his way to become a banker, and so complete was "Tech thoroughness" that he has made good in this, formerly to him a foreign profession.

THE CONCEPTION OF POWER OF MAGNITUDE

THE mind of the engineering student is made up during his college years of a number of perplexities, and his time is to a large extent spent in his numerous or continued attempts to solve his mental problems. One of the most serious of all his difficulties—and one which is inherent, we might say, to the college student—is his lack of ability to appreciate magnitudes and degrees of power.

Imagine the student in a class of applied mechanics. The professor reads the problem: " . . . a load of 1,000 pounds is concentrated at the center of a ten-foot beam." One would be surprised to find that probably only one or two out of the class of thirty have any idea at all of the magnitude of the force—a load of 1,000 pounds. Provided the student can think with greater rapidity than his classmates and professor, and assuming that he is exceptionally alert and inquisitive —that he has a natural yearning for specific information he will immediately attempt to conceive the magnitude of the load. If he has been brought up on a farm he will imagine the weight of the average farm horse—which is about 1,000 pounds. If he has had occasion to observe weights in a warehouse, he will compare this hypothetical 1,000 pound load to the weight of a barrel of cement, or to the weight of a sack of flour. He will imagine not simply an arrow and figures "1,000" but

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he will see piled up on that beam four kegs of nails, three barrels of cement, or the ponderous form of a farm horse. And the problem immediately becomes one of interest to him.

In this age where photography and photo-engraving have become a science, even greater precaution must be taken in the matter of creating impressions. A student looks at the photo of the dome on the New Technology. The building of which it is part has been well planned and accordingly the surrounding pillars and concrete work are in correct proportion. How then is the student to gain any conception of the magnitude of the dome? He compares the concrete supports with the concrete pillars on perhaps a store building under construction near his home. The dome will then appear to be probably twenty feet in diameter. He remembers a steel arch he saw on some bridge—and accordingly the dome assumes proportions so great as to stagger the mind. But what *will* give him the correct conception of magnitude?

As the student's mind is trained to reason with the proportionalities that exist in language, in mathematics and even in historical subjects, so his mind should be trained at the same time to grasp the proportionalities in their *abstract* sense. One of the most impressive examples which have come to our notice, wherein a professor brought home his point, occurred some time ago in a recitation in physics. The question arose concerning the divisions of a meter rod—first into decimeters, then into centimeters, then dividing these each in ten parts or millimeters, and finally into microns. "In order to grasp the sginificance of this enormous number of divisions of a meter rod," said the professor, "let us make a comparative consideration. You see before you one hundred thousand divisions of a meter rod. On the clearest night, if you stand on top of a high building with an unobstructed view of the horizon, you can see scarcely five thousand stars."

In this way the professor helped to overcome the difficulty existing in the students' mind—he gave them a comparative standard of value. Because he understood the value of the appreciation of magnitudes, he gave to his students a measure which they undoubtedly use every day of their lives.

Aside from its mere intrinsic value to the student in appreciating magnitudes, this comparative view of things will do much to develop his latent mental powers. Soon after a student has learned to think enough faster than necessary to fully grasp one idea at a time he will be able to think of two things at once,—to divide his attention between the subject at hand, giving it the necessary amount of attention, and some other consideration which is possibly of more importance. He will be able to grasp the context of a lecture and to rest at the same time. His mental power will be double what it was previously, or his energy output halved. To the young engineer, without experience to steady him, this conception of magnitudes and appreciation of comparative measures is one of the factors essential to his success.

IN accordance with Major Briggs' renewed opposition to the idea of the naming of the athletic grounds at the New Technology "Briggs Field" we think that in respect for him the proposition should be no more discussed at present.

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HARVARD GRADUATE NOTES

'85—F. A. Delano, formerly in Chicago, as president of the Wabash Railroad, is now Vice-Governor of the Federal Reserve Board, Washington, D. C.

'99—Prof. James A. Moyer, head of the Department of Mechanical Engineering of Pennsylvania State College, has been appointed Director of the University Extension of the State of Massachusetts, which is a new department, with offices in the Ford Building, Boston.

'04—Donald W. Davis, president of the Ohio Pipe Co., died at Findlay, Ohio, on July 19.

'07-'09—Murray E. Brookman, formerly of the firm of Brookman & Cragin, Miles City, Mont., is now with the Minnesota Loan & Trust Co., Minneapolis, Minn.

'12—L. N. Clinton is with the J. Edward Ogden Co., 147 Cedar Street, New York City.

'15—J. R. Tuttle is with the Buffalo, Lockport & Rochester Railway, at Rochester, N. Y.

'15—Martin L. Wiener is with the Greenfield Tap & Die Corporation, Greenfield, Mass.

'15—F. C. Millspaugh is employed as Assistant Engineer for the Filter Plant of the Gardiner Water District, Gardiner, Maine.

'15—Henry Daniels is with the Pennsylvania Railroad Co., at Pittsburg, Pa.

'15—A. B. Gardner is with the N. E. Westinghouse Co., at Springfield, Mass.

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A FEW FORMULAS AT THE CHEMICAL SOCIETY DINNER

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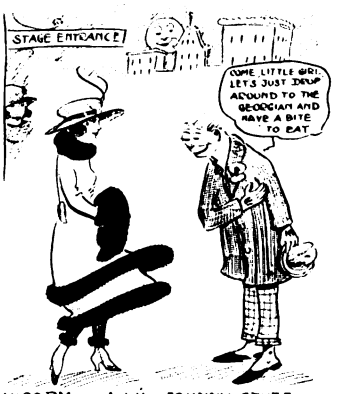
8:00 P.M. — A PEEK AT THE MOVIES

9:00 P.M. — A BEER? OR SO AT THE MAYWARD

10:00 P.M. — JUST LOOKIN 'EM OVER DOWN IN CHINATOWN



11:00 P.M. — A LIL JOHNNY STUFF AFTER THE SHOW'S OVER

12:00 P.M. — GIVIN' HER JUS'-HIC-A LIL PLEASURE AT THE GEORGIAN-WHAT!

5:00 A.M. (PERHAPS 7:00) — HIC-HOME-AT LAST

A TECH MAN SURE DOES KNOW HOW TO ENJOY AN EVENING

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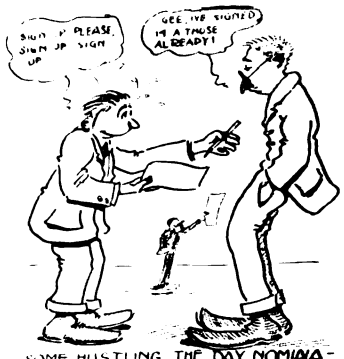
MIDNIGHT

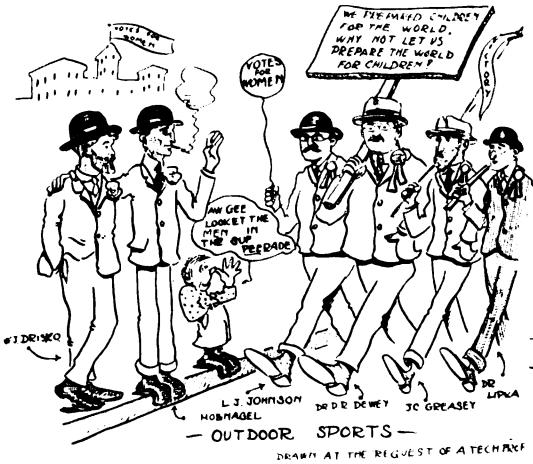
1:00 AM



SOME HUSTLING THE DAY NOMIAA-TIONS CLOSED.

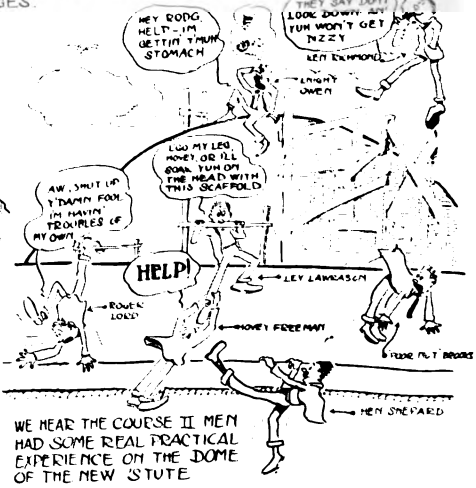
SOME REAL POLITICAL STUFF AT THE UNION

DON'T GET EXCITED THIS IS MERELY A MONTHLY JOY RIDE - IT HAPPENS IN THE BEST OF COLLEGES.



— OUTDOOR SPORTS —

DRAWN AT THE REQUEST OF A TECH PROF



WE HEAR THE COURSE II MEN HAD SOME REAL PRACTICAL EXPERIENCE ON THE DOME OF THE NEW STUTE

JUST A FEW PICK-UPS DURING THE MONTH

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A GLANCE AT FIELD DAY AND TECH NIGHT

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THE KALENDAR

DECEMBER

1. *All* men having "Ds" make them up by this date, 1948.

2. "Watchful Waiting" brings peace and prosperity to Mexico, 191-(?).

3. Convicts made to work on fortifications, 1864. At the New Technology Freshmen will probably have to dig trenches, 1916.

4. Lucifer (Brimstone) matches invented, 1830. Still the most popular kind of matches (except weddings) in Boston, 1915.

5. Chess introduced in Europe, 700 Chess introduced in M. I. T., 1913. It took it a d—— long time to get here.

6. The opera house in the Haymarket burnt down.*

7. William Barton Rogers, founder of the greatest scientific educational institution in existence, born, 1804.

8. Black lead pencils first used. Part of the same lot is still on sale at Andy's.

9. Life-boat invented by Greathead, 1789. Some head!

10. Matthias W. Baldwin, pioneer locomotive builder, born, 1795, his pioneer locomotive being used at present in hauling suburban trains on the B. & M.

11. Spectacles invented, 1290. The same kind of tortois-shell (or rather a celluloid imitation of the same) worn by Tech Seniors (?), 1915.

12. Dreadful colliery explosion at Barnsley, England, 1866. This was not due to a Zeppelin raid, however.

13. Cut out by the censor.

14. Latent heat discovered by Black, 1762. Junior in Phys. Lab. discovers a new value for the same, 1915.

15. Jamaica discovered by Columbus, 1494. It was not Jamaica Rum that attracted him there, as the Jamaicans invented it after he discovered them.

16. Arlo Bates born, 1850.
Also, the longest tea party ever held, at which 840 chests of tea were consumed, met at Boston, 1773.

17. Hydraulic Press invented, 1796.
Hydraulic Squeeze, a new one-step, demonstrated at the Mid-Winter Concert, 1915.

18. Death of the Marquis (pronounced Markee) of Wellesley.**
Several Tech students lay claim to the title.

19. Gas for lighting adopted in London, 1814. Adopted in M. I. T. labs. when the power plant stops due to the power plant test by Course VI Seniors.

* London, 1867.

** 1842.

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20. Palace of Westminster built, 1840. Profs dine im Keller of the Westminster after 10 P. M. (See cartoon section of this issue.)

21. Liberation (adv.) of Abd-el-Kader, cousin of Omar.*

22. Rhodes taken by the Turks, after a five months' siege, 1522.
The Turks can have the roads, we prefer to walk on the sidewalks.
Great sorrow expressed at starting of vacation, 1986.

23. The solar year found to consist of 365 days, 5 hours and 49 minutes; 285. Editor's note—This 49 minute precision in 285 is nonsence. Prof. Goodwin did not write "Precision of Measurements" until 1908.

24. Battle of Wakefield.**

25. Several Tech men make up on this day for much previous "grub" at Hayes.

26. Coaches first seen in England, 1565. Same type frequently seen in Back Bay, 1915.

27. Course VII student travels in Bactriana. Returns with specimens.

28. Woodrow Wilson born, 1856.

29. The Belgae conquered by Caesar. 57 B. C.
The Belgae conquered by Kaiser 1914. (Kaiser is the German equivalent for Caesar.)

30. Back to Hell again. The names of everyone cutting classes this day will not be sent to the Faculty, 19∞.

31. HNO_3 and H_2SO_4 first prepared, 800.

* See page 52 of the June issue.
** 1460.

AN INKLING

Ima Nut—Does your fountain pen leak that way all the time?

Soami—Oh my! no. Just when I have ink in it.—Widow.

AT PALM BEACH

Cynthia—"These bathing suits make people look shorter, don't they?"

Tom—"And people look longer, too!"
—Judge.

By waving a copy of Ye Crabbe, a subscriber saved a runaway horse from being killed.

O ye power of ye press!—Vermont Ye Crabbe.

Whenever a man begins to take himself very seriously everybody with a sense of humor moves up nearer, so as to miss nothing.—Puck.

ALL RIGHT MINNIE

Jack—Did you get through all right?

Art—Well, I'd have made it, but my Prof. saw me on the street with a book, thought I was trying to swipe it and conned me.—Minnehaha.

She: Yes, I might find a bite for you, if you'll saw and chop a good pile of wood, bring in a few buckets of water, clean up the back yard and fix the front fence.

Malachi: Maddim, I'm only a hungry wayfarer: I ain't your husband.—Ex.

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LOCAL COLOR

AT THE ONION

Prof. Kurlingiron: "Waiter! How is this, I find a needle in my soup?"

Freshman Waiter (once a typesetter) "Oh, Sir, that's a misprint, it should have been noodle."

PHYSICS HEAT

Brooks: x-z-x-z-z-z-z (sawing wood—you know the way).

Nearby: Haw, Haw!

Neighbor: What's the rumpus?

R. F. F.: I guess I fell asleep.

Neighbor: You *guess* you did—you know damn well you did.

IN ECONOMICS

Teacher professing to be instructor: "What is the difference between price and value?"

Would be Bright One: "The value may be 10 cents and may look like 30 cents."

She—This is the first pumpkin pie I ever made.

He—But you had a good receipt, didn't you.

She—No, I made it out of my head.

He—Then I should say it was squash.

Grouchy Frosh.: Gee! the expenses at "Tech" are fierce. And half the stuff you pay for you never get.

Upperclassman: Yes, but half the stuff *you* get you never pay for.

Prof. Vogel: Adam was the first man to speak, Eve the first woman to listen,—or the other way about, judging from the Characteristics of the Specie.

In Lithology

If epidemic is epidote what kind of harmony is hornblende.

After suffering a long time with toothache the young colored girl got up her courage enough to go to the dentist. The moment he touched the tooth she began to scream.

"Look here," he said, "you mustn't yell like that. Don't you know I'm a 'painless dentist?'"

"Well, mebbe yo' is painless, sah," she said, "but Ah isn't."—Ex.

The teacher wanted some plums in order to give an object lesson during school hours and calling one of the small boys she gave him ten cents and dispatched him to the fruit stand down on the corner.

"Before you buy the plums Willie," she cautioned, "you had better pinch one or two to make sure they are ripe."

Little Willie flitted away. Soon he came back and smilingly put the bag on the teachers desk. "Oh thank you Willie," said the teacher taking up the bag. "Did you pinch one or two as I told you to do?" "Did I?" was the gleeful response, "I pinched the whole bagful and here's your ten cents."—Harvard Lampoon.

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'19—I suppose you're glad to get back again, are you not?

'18—You bet; I've been working all summer.—Ex.

Scene: Beautiful background of trees and moon above. In the foreground are lovers kissing each other, blissfully.

Question: What is wrong with this picture?

They are married—but not to each other.—Ex.

"Is she a brunette?"

"No; she's very light."

"Are you sure?"

"I ought to know. I picked her up."—Jack-O'Lantern.

"Then you didn't ask for her hand?"

"No; when I went to interview her father he was busy with the furnace. He said to come down, and after watching his struggles for half an hour I decided I didn't want to get married.—Ex.

"Young man," said the irate old gentleman at the lunch counter to the hard-looking youth who was inhaling his soup with a gurgling sound and splashing it about the while, "what are you? A Colorado geyser?"

"Naw," replied the soup juggler, "I'm a New Jersey guy, sir."—Ex.

Cohen—Vy Ikey iss it der loaf uf breadt like der sun?

Ikey—It rises in der yeast and sets in der vest.—Ex.

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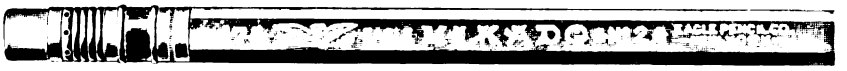

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'15—Gee, that was a pretty flossy present, wasn't it?

'16—Yes, but I got the rouge all back when she thanked me for it.—Lehigh Burr.

One frat man: Got much room in your new house Tom?

Another frat man: I should say not. The kitchen and dining room are so small we have to use condensed milk.—Punch Bowl.

Don't you admire the way she dresses?

I don't know, I never saw her.—Lampoon.

"Now Dorothy," said the teacher to a small girl, "What is a panther?"

"Yeth mam, a panther ith a man who makth panth."—Ex.

Why were you late?

My watch was slow.

That so? That's from going with you so much.—Lampoon.

"THAT'S where I shine," he said as he pointed out his blue suit to the tailor. —Ex.

He—She appears to have changed her clothes.

Him—Most people disappear to do that.—Jack-o-Lantern.

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DEEP STUFF

Blessed is he who walketh not in the counsel of the upper-classman for verily I say unto you he will land in the hock-shop.

Humility becometh a freshmen, for he who walketh with downcast eye often findeth a nickel.

Go to the moth, thou freshman, consider its ways and be warned, for it flitteth all the night about the bright lights and when morning cometh, lo it is burnt.

A wise freshman maketh a glad father, but a foolish one causeth great grief to the bank-roll.

Early to bed and early to rise gaineth a freshman naught but late hours and much wisdom.

Beware of the food of the hash house, for he who eateth in glory at the Union sleepeth in agony at the student ward.

Blessed is he who sitteth on a red hot stove for he shall rise again.—Exchange.

A New York man was recently acting as a guide through an art gallery for a friend from the country. As they paused before a statuette, the guide said:

"That is Psyche. Executed in terra cotta."

"What a pity," said the rural one. "How barbarous they are in those South American countries."—Ex.

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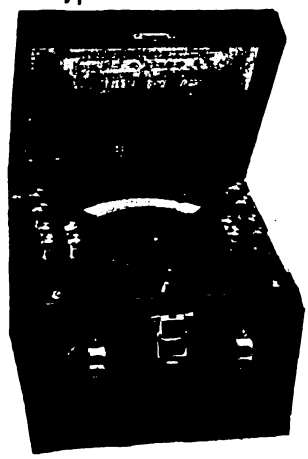

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For complete information regarding Model 329 Wattmeters write for Bulletin 2002. Other models in this group are Model 310 Single-Phase and Direct Current Portable Wattmeter, described in Bulletin 2002; Model 370 A. C. and D. C. Ammeter, described in Bulletin 2003; and Model 341 A. C. and D. C. Voltmeter, described in Bulletin 2004.

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Harry—May I have the pleasure of this dance?

Carrie—Just a minute—I-er—

Harry—(offering his arm)—Well, if you want to hesitate let's go out on the floor.—Stanford Chaparral.

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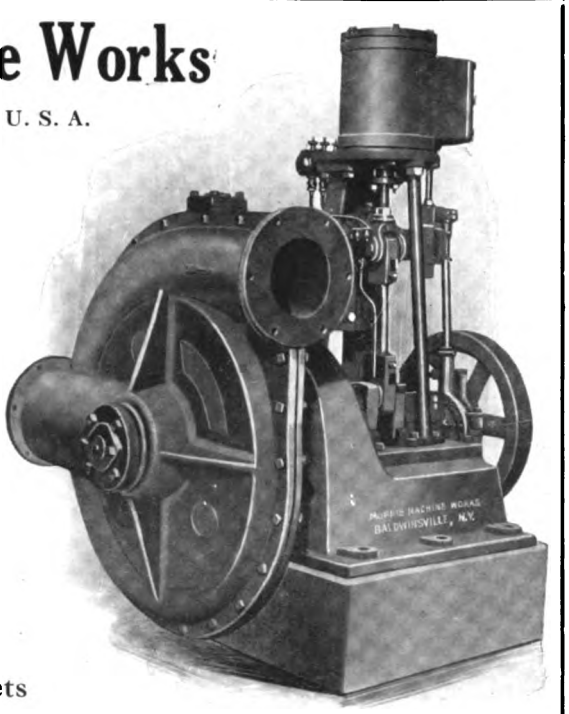

"I had a dreadful fall last night."

"That so; tell me of it, Egbert."

"My wife was talking; I hung on every word, and then, and then,—"

"Yes, yes, go on."

"—and then her voice broke."—Lampoon.

Bowery Sal—"I want a job. I kin do anything, see?"

Floorwalker—"Sew?"

Bowery Sal—"Yes, dat's so, you big stiff, an' if you get fresh wit me I'll bust you on de beezer, see?"—Jack O'Lantern.

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Mary (thrilled)—Mm, I should say he does.—Jack-O'Lantern.

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Deedle—I ought to, but I don't.—Jack-O'Lantern.

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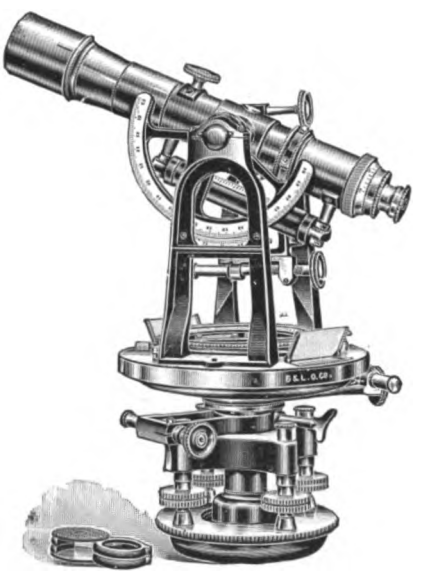

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Jan. 1916 Vol. II, No. 6

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Copyright, 1915, by The Technology Monthly

Entered as second-class matter at the post office, at Boston, Mass. Published monthly during the college year by the students of the Massachusetts Institute of Technology. Publication office, Technology Union Building, 42 Trinity Place, Boston. Harvard Editorial Office, 218 Pierce Building, Cambridge, Mass.

Mail Address: Technology Monthly, M. I. T., Boston, Mass.
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The Finishing of the Catskill Aqueduct

TRAVER HOLLOW BRIDGE AT ASHOKAN RESERVOIR

A 200 foot span, three hinged arch of reinforced concrete. This bridge carries one of the new highways over one of the feeders of the reservoir at a height of one hundred feet above the stream-bed.

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THE TECHNOLOGY MONTHLY
AND HARVARD ENGINEERING JOURNAL

VOL. II BOSTON, MASS., JANUARY, 1916 NO. 6

FINISHING THE CATSKILL AQUEDUCT

By ALFRED D. FLINN
Deputy Chief Engineer, Board of Water Supply of New York

Editor's Note. Mr. Flinn's article brings out exceptionally well one of the phases of engineering practice upon which any engineer, especially a young one, is likely to slip up. Mr. Flinn, as next in charge under the Chief Engineer, Mr. J. Waldo Smith, M. I. T.,'86, has been intimately associated with a large number of Harvard Engineering School and Technology men.

FINISHING a great engineering work like the Panama Canal, the Catskill Aqueduct or an extensive transportation system is a larger and more important part of the whole undertaking than occurs to superficial thinking. It is accepted as a matter of course that many months and even a few years should be consumed in surveys, investigations, preliminary studies and perfecting of designs in preparation for active construction. Progress is satisfactorily evident while the noisy drills, the steam shovels and the concrete mixers are running full days and the works are swarming with men. But when the construction plants have been dismantled and the labor forces disbanded, the public, or the directors, or the commissioners are likely to grow impatient and wonder what the engineers are doing and why the new property is not put into service.

At this stage of the work, the engineers in charge must meet some of the greatest demands upon their tact and courage as well as upon their efficiency, skill and patience. Every civil engineering enterprise of great magnitude is in many particulars different from any other and, therefore, is to some degree experimental. Furthermore, progress in the arts and sciences introduces new conditions. Consequently some features of the works must be carefully tested before being put into service, and frequently much of this testing cannot be done until the whole or a large portion of the system has been nearly completed. Such tests commonly reveal some faults which have to be corrected and some unsatisfactory results or conditions which were not foreseen, and, perchance, could not have been predicted from knowledge previously in hand. Then, too, there are many pieces of minor equipment to be procured, installed and adjusted, and,

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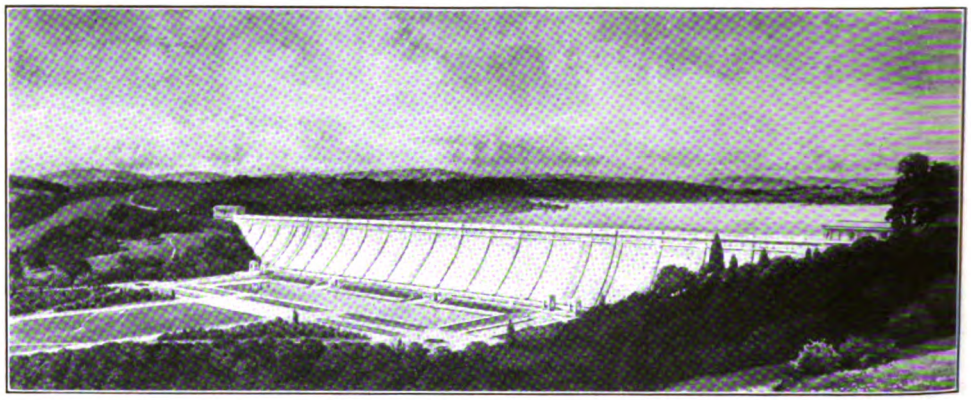
not least of all, adequate records should be made for the information of those who are to operate and extend the works. These items of work are often tedious and seem to consume a disproportionate amount of time; and they take men of technical skill and training, so that the percentage of engineering to construction expenditures mounts up to high figures. But this part of the work is quite as important as any other and should be well done.

A great aqueduct or power development or transportation system at the time when the superficial onlooker thinks it is "done" is not unlike a large building when the walls and roof are completed or a great ship at her launching. And disbanding a large organization of engineers is only less difficult



KENSICO DAM, 30 MILES FROM NEW YORK CITY HALL

It is of cyclopean masonry and has its downstream face covered with cut granite. There is to be a large pool in the foreground. The reservoir has a total capacity of thirty-eight billion gallons

Meanwhile, however, the engineer is having no small harassment. Under pressure for curtailment of expenses he has in too many instances reduced his forces, especially by dismissing "the more expensive men," until his staff is not sufficient for the tasks remaining to be performed, either in numbers or ability. Frequently the abler and more alert men, or many of them in the various ranks, have left of their own initiative all too soon, foreseeing "the end of the job" and knowing by experience that if they allow good opportunities to slip in order to finish the work in hand, they have small chance of being kept on the payroll at the end long enough to find other opportunities. Fortunately, these conditions do not always obtain, but to some degree they are not uncommon.

than assembling it—and it is a much less enjoyable task, particularly in "hard times."

However, finishing has another and happier aspect. There is the satisfaction of seeing structures take material form which have existed previously only in the mental conceptions of the engineers. There is the joy of having overcome difficulties. Pleasant associations have been formed and strengthened. A great service has been rendered to a city, a state, a nation, or to many such units.

In many instances most of the structures which have required so much

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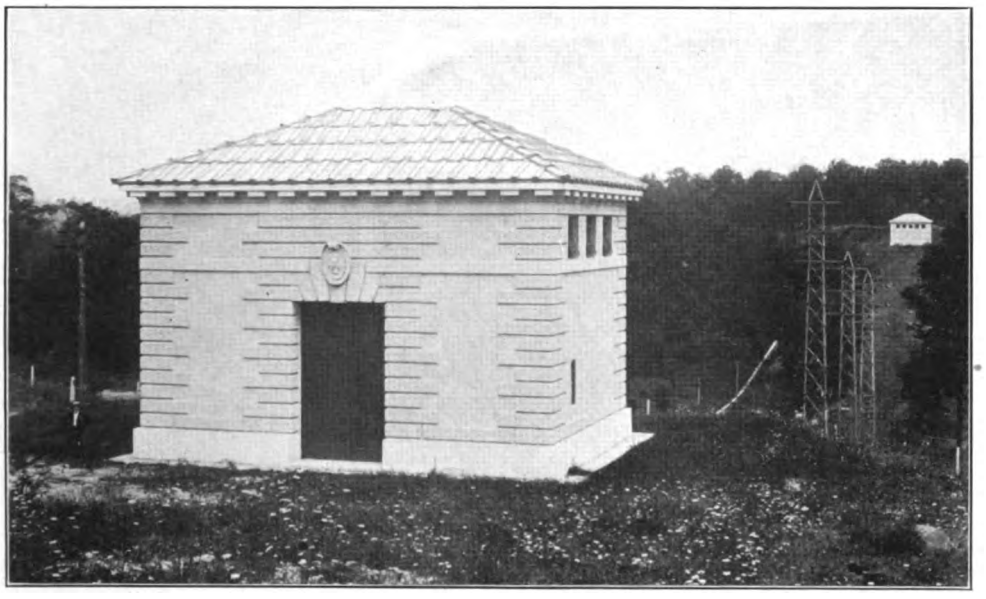
thought and labor are, when finished, concealed beneath the surface of the earth. This is largely true of the Catskill Aqueduct. Long mounds of earth mark the location of the cut-and-cover portions. The earth and masonry dams are only partially visible. Tunnels and pipe lines and many of the controlling works are wholly out of sight.

signing the buildings and the masonry dams and some details of the bridges on the relocated highways around the reservoirs, which should be added to the list of visible and pleasing structures. Indeed, the highways themselves and the forested and planted areas on the reservoir margins and along the aqueduct might be added,



ELMSFORD STEEL PIPE SYPHON

This is one of the fourteen relatively short steel pipe lines in the Catskill Aqueduct crossing shallow valleys. The view shows one of the types of superstructure for small gate-chambers. Attention is directed to the reinforced concrete roof tiles. These buildings are of synthetic stone ("cast granite").

Superstructures built over some of the gate and screen chambers and other underground structures, and the water surfaces of the reservoirs are, with the exposed portions of the masonry dams, the most noticeable visible reminders of the many millions of dollars' worth of work.

It is only fitting, therefore, that the visible structures should be made pleasing in appearance as well as useful and enduring. To this end architects have collaborated with the engineers in de-

too, although few persons will think of them as appertaining to the waterworks. Better than many words, a few pictures will show the character of the landmarks of the Catskill Aqueduct and its reservoirs.

In signalizing the finish of any great engineering project, it should be borne in mind that although a few men have been prominent as the leaders, the total achievement has been wrought by many, some of whom have not been even indirectly connected with the

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organization. Indeed, any such great achievement is the product of nothing less than the civilization of the community which has been sponsor for the undertaking. Nevertheless, credit is due to those men and women in particular who have borne the burdens, from the commissioners and chief engineer down. Here can be mentioned by name only the chief engineer, Mr. J. Waldo Smith, who from the beginning has successfully directed the work up to the finishing stage, in which it now is. Under him many Harvard and Technology men have served faithfully and with credit in various ranks.

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THE FRIENDSHIP OF BOOKS

By FRANK AYDELOTTE
Professor of English, Massachusetts Institute of Technology

Editor's Note. Professor Aydelotte is now enjoying his first year in the English Department of the Institute. Coming to us after having taught in several western universities, his experience with human nature has been wide and varied. "The Friendship of Books" is an article which grows on one with each reading.

A GREAT deal of nonsense is always being talked about the "friendship of books." Young people are always being told how at the expense of a few dollars they can so stock their bookshelves as to obtain the companionship of the greatest minds of all ages at whatever moment they desire it, day or night, for as long or as short a time as they will. It is a common habit of men of my profession to reprove the young for not taking advantage of this opportunity and to be very severe upon them for seeming to prefer, instead of this noble band of the best of all ages, the friendship and society of quite ordinary minds of the present day, which have only the accidental advantage of being clothed with flesh and blood.

I cheerfully confess to a leaning towards flesh and blood myself. I am not always sorry when the coming of a friend causes me to put aside the book with which I am engaged at the moment, and I have not observed that boys or men are likely to be on terms of more solid intimacy with their friends in paper and covers for failing to cultivate those in trousers and skirts. Most authors were human beings before they were books, though many readers and teachers of literature sadly fail to realize this fact.

Nevertheless a certain excuse must be made for even the most pedantic talk about the "friendship of books," and for the use of the terms companionship and acquaintance in connection with them. Books are remarkably like persons after all, and our dealings with them are likely to have some suggestion of a personal relation. It may be that of a bowing acquaintance (and the bow may be only the nod of polite toleration or it may be the cringe of fear) or the warmer sense of companionship, while the feeling of a good reader for a great book is hard to express by any other word than the love which he bears for his friend.

Leaving out of account for the moment the matter of material advantage in the case either of books or friends, I think we can say that books may give a man service of the two most important kinds which he gets from his friends—pleasure and stimulus. Serious people who have taken in hand the education of the young are shamelessly lacking in their part of the debt of gratitude which the race owes for pleasure derived from bad books. By bad I mean of course bad from the point of view of literary art. This pleasure is like that which we derive from friends who would cut rather a poor figure as models for the race; they have plenty

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of faults and yet we like them and derive from them (among other things) amusement for untold idle hours. So with authors who are not great but who do their work sincerely and whose books, whatever the faults which critics may find in them, while away for us the long hours of a journey or a convalescence or an evening when our thoughts are tied in a knot and work is torture. The refuge of books in all such situations is simply priceless. Not that there is much need to dilate on the fact, for the great common herd of men know it, and the enormous editions which the publishers sell of all kinds of amusing books bear witness to the effectiveness of the demand.

The pleasure to be had from books is one of the finest in the world, but the stimulus which comes from them, if rarer, is still finer. This is the best service of the best books—to bring a man up to his best at all points, in thinking and feeling and action—just as it is the highest service of a true friend. It is here that books compare best with living friends: their influence may be less powerful but it stretches further. They are and must be the principal resource of the rarer minds of every age. In the world of thought books live a different life from that of men who walk on two legs, but no less real. They are recreated again and again in the minds of thinking men, so that Shakespeare and Plato will make their comments on the affairs of today and tomorrow and next year with the same regularity as the editor of a daily paper.

In all these respects we must capitulate to those who talk about the "friendship of books." What other word will so well express the service which we get from them? After all it is not so much the use of the word friendship which one objects to in the conventional exhortations as it is the conditions upon which the young are told that this friendship is to be had. These conditions are not so easy as they are commonly represented to be: on the contrary, they are very hard. They are not at all a matter of a few dollars or of many; the friendship of books is not open to everyone who can acquire a certain number of volumes of the works of the best authors. The conditions are quite other than that and quite commonly misunderstood.

The first and most important condition of having a book for your friend is the ability to put yourself upon an equality with it. The disposition to treat a book as an oracle, as the utterance of some miraculous power known as genius, the ways of which are past finding out and the pronouncements of which are not to be questioned or gainsaid—this disposition is responsible for thousands of unread volumes. "Perhaps there is no equality in the realm of political thought," Sir Walter Raleigh has said somewhere, "so exacting as the equality which a great poet demands of his readers." A great writer does not talk down to his audience any more than a great teacher. He looks at the reader squarely, with a level eye, and the real reader returns the gaze. Here again the analogy of friendship is illuminating. A man does not form friendships with his superiors or his inferiors, or at least the existence of friendship causes the inequality to be forgotten. As long as it is remembered, as long as the relation is that of master and servant, or king and subject, or benefactor and person benefited, or pedant (I do not say teacher) and scholar, so long is real friendship impossible. To

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be capable of friendship a man must be capable of ignoring these distinctions, of looking at his friend as a fellow human being, as another mind and soul with which he enjoys contact. It is the same with books.

A great author does not write to be believed or admired unquestioningly. He writes to make men think and he wants no admiration or approval which are not the result of intelligent thought. You insult him when you compliment his work and show at the same time that you do not understand it. You give him the highest praise when you show that his work has influenced your thought, though you utter no word of adulation.

To read a great book adequately a man must be an individual, with a point of view his own: he must own his own soul. He must think as he reads, trying what the author says by his own standards, believing what is true for him, rejecting what is not. This does not mean that a man should be cocksure, that humility should have no place in his soul. The right kind of humility is not, I think, inconsistent with the point of view I have indicated. True humility is only the reverse side of the picture I have drawn. It is the realization that, while what is true and admirable for another man is not necessarily true and admirable for you, neither is your truth necessarily his. It is the realization of the infinite variety of human nature which is necessary to having any intelligent point of view of your own. Each of us is an individual, in some respects like all others, in some respects different from any. Each of us must face life for himself, must make his own solution of its eternal mysteries, and must live by that solution and face life and eternity with it. No man can borrow another's solution of this great problem, be he never so devoid of scruples against doing so. Each must think it out for himself; no thought that he cannot think can be true for him; it is the bow of Ulysses which he cannot bend. We are all different and yet we are all alike; the thought of another may be of infinite service to us in thinking for ourselves; and the thoughts and intuitions which seem true to us become our own just as the food we eat becomes a part of our bodies. Humility, that kind of humility which is worth having, is the realization of these two facts.

Another condition imposed by the law of things upon the person who would have the friendship of books is intensity, the power of concentration, the ability to rise to the level of lofty thought and feeling. There is I suppose a good deal of bodily laziness in the world, but the amount of intellectual and spiritual laziness is infinitely greater. It is fatally easy to live day by day and to do a lot of apparently useful work in the world by rule of thumb, without thinking at all in that intense or concentrated fashion in which all a man's experience is focused upon the problem in hand and ideas and feelings are fused into the very fabric of his mind and character. It is easy to live without thinking in this fashion (which is the only mental process worthy of the name) in every walk of life, as easy in dealing with books and in writing and talking a great deal about them as it is in dealing only with machines and hand tools. But a man whose mind never works in this intense fashion can never be on intimate terms with a great book. Ideas were never meant to be kept in a cool dry place; they come flaming from the minds

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which create them and they can be received only when the reader's thought is equally intense.

Of course books and authors differ widely in respect to the intensity of their thought and feeling and in respect to the intensity which they require of the reader. But the great books are greatest in this, that the man who is intellectually lazy can never be on any terms which could be called friendship with them.

Doubtless there are many other qualities which are desirable to fit a man for the friendship of books, but I shall not undertake here to make an exhaustive list. Instead I shall take a few moments to speak of two which are popularly supposed to be necessary but which in my opinion are not so at all. These are knowledge about books, and fastidious and critical taste in judging them. Both are certain to come from any long continued friendship with books, and I, who spend a great deal of time trying to inculcate both in the mind of the young, have no intention of undervaluing either. But neither is necessary for a start; and neither, as ordinarily understood, should be the young reader's first aim. We do not form a friendship for a man because of what we know of his family or his history or his virtues. We judge his personality for ourselves and our friendship may continue in spite of quite obvious drawbacks in each of these three particulars. It is so with books and authors. Every man must make his own list of the hundred best books. A man's admirations must be a part of his own character; it is unsafe to found them upon the admirations of others. It is still more unsafe to form one's dislikes upon the opinions of other people, and in this matter of reading, as in most other business of life, the positive qualities of admiration and sympathy have a value immensely greater than the negative ones of disdain and critical fastidiousness

The way to read is to follow your individual tastes, to let one book lead to another, to re-read time and time again what is most interesting to you, to cling to the book which improves on re-reading and to break with the one that does not, to look your author squarely in the face, and to meet his thought with your own, shrinking from no effort to follow the train of his reasoning or to rise to the height of his emotion. The man who follows that course may not be able to pass an honor examination in English literature, or even an examination for college entrance, but he will be in a fair way to enjoy the friendship of books.

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FOR some time I had been longing to commune with nature and to enjoy the care-free life of the camper. I had been racking my brain for a profitable way to gratify my desires, when suddenly, like a bolt from the blue, the idea came to me. I would conduct a summer camp for boys.

There was no trouble in corralling a party of boys. Every youngster in that section of the country, it seemed, wanted to go camping, and every loving parent was perfectly willing to fork over the required payment—for, of course, this affair was to be run strictly on a business basis. My finances at that time demanded it.

The farmers in that neighborhood had the reputation of being close, and the way they flocked around to pay their money and make sure that their sons would be among the party surprised me. Later my surprise wore off and I now think that I could have doubled the fees without hearing a word of protest.

We set out for camp one beautiful July morning. I had hired three old wagons—the first carried my party of fifteen healthy youngsters, the second was laden down with the camping outfit and myself, and the third conveyed the culinary department. The sun was warm and the birds sang. Everything pointed to a splendid time.

The horse attached to the camping outfit had been a splendid animal about ten years previous. He seemed possessed with the idea that the wagon was planning to sneak off and leave him; every now and then he would stop and look sorrowfully around to assure himself that the outfit was still in his vicinity.

As a result the distance between the two wagons steadily increased, and my camping party disappeared round a bend in the road. Not for long did I lose them. A moment later came a series of blood-curdling yells. The driver whipped up his horse, and as we careened around the corner at the giddy speed of five miles an hour, we came upon my youthful charges, who were earnestly engaged in pelting their driver with anything handy and hopping around like a band of Sioux Indians.

When the excitement had calmed down one of the ruffians explained that they were playing "holding up a stage coach." Right there I decided that my trip was not going to be one continuous round of pleasure.

"Get back there in that wagon and behave yourselves," I said severely, "or you don't go another foot!"

At this, the driver felt called upon to say something. "Begorry, not another foot do I cart them critters till I've received recompense fer me injured dignity, not to mention a cut on the nose," he stated emphatically. He then used

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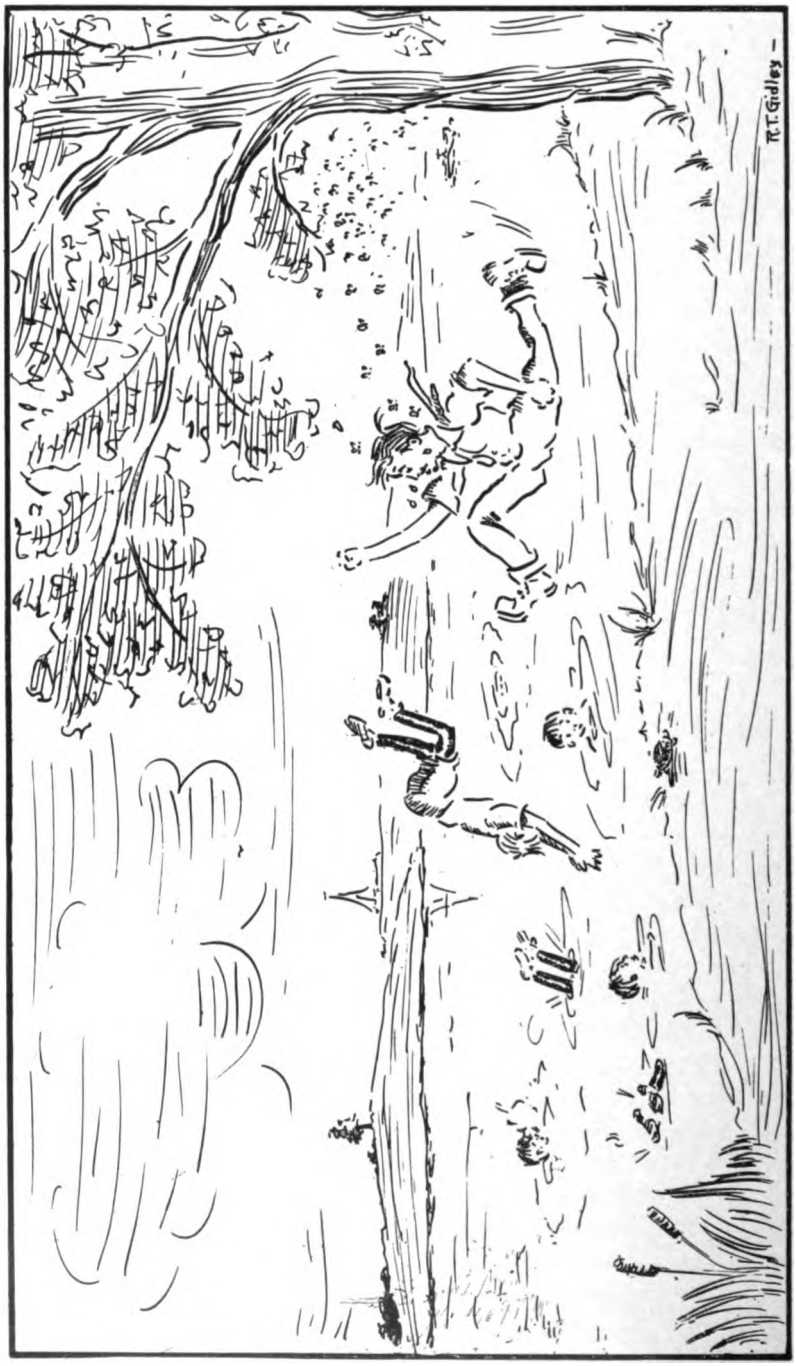

One of them picked a hornet's nest out of a tree with a stone very cleverly, and I managed to outdistance all but two of the inmates.

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some hard language. He was not a religious man.

I paid him and mentally deducted the amount from my profits. I began to feel slightly uneasy. However I shifted my position to the first wagon and we arrived at our destination without any serious mishap.

The spot selected for the camp was an deal one in the midst of a grove of trees near a lake. The boys worked like beavers, and my misgivings began to vanish. Soon our little camp was erected and we started out on a tour of exploration.

The boys were frolicsome—and playful. One of them picked a hornet's nest out of a tree with a stone very cleverly, and I managed to outdistance all but two of the inmates. When, after an enforced bath in the lake the lad explained it was only a joke, I promptly forgave him. Thank goodness I have a sense of humor.

That night it rained. I occupied a tent with some of the older boys, and lulled by the patter patter of the rain on the canvas roof I soon fell asleep.

I am a sound sleeper. In the middle of the night I awoke with a start. The rain was coming straight down into my upturned face,—and it was no gentle drizzle either. I had been carefully moved out of the tent into a clearing by that band of young ruffians.

I was thoroughly drenched and felt decidedly put out. The next morning a rigid investigaton disclosed the instigator of the plot and I ducked him none too gently in the lake. He left the camp vowing vengeance. Later in the day he returned, accompanied by a strapping parent who announced in no uncertain language that he was going to lick me. I took an instant dislike to him. He was not a handsome man but he was a thorough one and a man of his word. At parting he declared that his innocent boy had taken a severe cold as the result of my cruelty, and that in case the lad did not feel better by night he would pay me another visit.

When he was well out of hearing I called and told him what I thought of

"Above me the bravest man in that section of the country was earnestly calling for someone to rescue him."

him and his rascal son, and announced that if he would come back I would duck him in the lake and be glad of the opportunity.

The next afternoon the cook came and told me he thought he had better quit.

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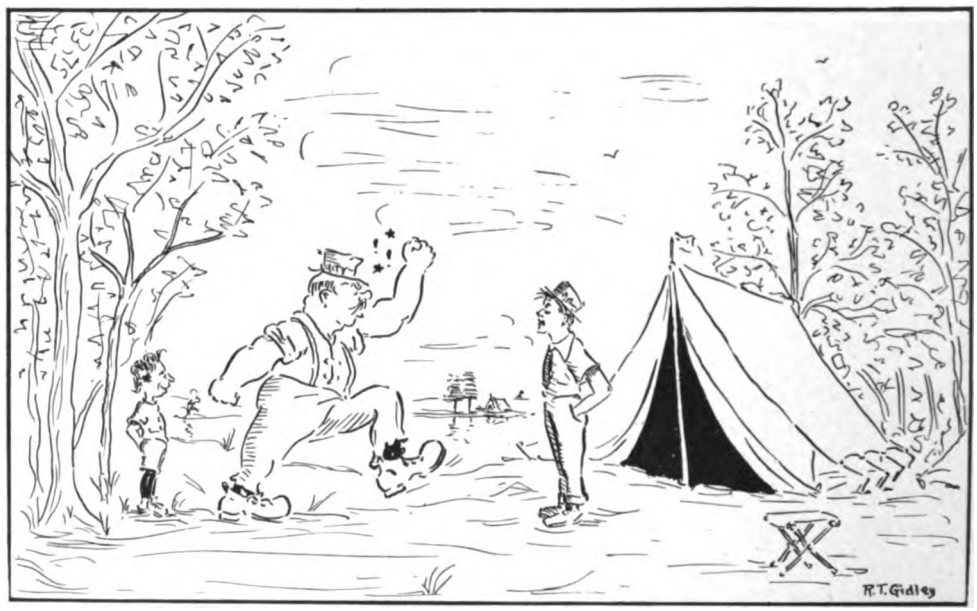
He was a family man with a wife and three children, he said, and besides, his health was none too good. Being a lone white man among a tribe of Indians did not appeal to him, he confided. He had been burnt at the stake twice and the third time he was afraid they might succeed.

He was a good cook and I hated to see him go, but his mind seemed quite made up.

that I began to be worried. I had determined to have the cook in the tent with me—just as a matter of precaution—and as I started to pull aside the flap and enter I heard a deep ominous growl. Some wild animal was within.

The next instant the growl was repeated. Instinctively we backed away, and as we did so a large shadowy form --about the size of a lion or smaller—plunged out of the tent straight at us.



I took an instant dislike to him

I was not vindictive enough to do the cooking myself, so leaving the camp in charge of the worst youth in the party I set out for town to hunt up another chef. I soon found a tall personage who said that he would cook for a gang of pirates if necessary. The stories that he told me of his personal bravery on the way back to camp convinced me that I had unearthed a treasure.

Much to my surprise the camp was still there when we arrived after dark. Everything was so quiet and peaceful

With a shout of warning to the boys I took flight. By the time I reached the foot of the nearest tree, the cook was nearing the top. I pulled myself out of the danger zone minus a quarter of one trouser leg. Above me the bravest man in that section of the country was earnestly calling for someone to rescue him.

The growls at the foot of the tree developed into business-like barks. I was somewhat relieved, but I made no attempt to descend. A dog can act real

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unpleasant at times, and I contented myself with calling down soothingly, "Nice doggie, nice doggie! Doggie want a bone?" Evidently doggie did, but I had no intention of letting him gnaw on one of mine.

That the barking did not annoy the boys surprised me. Perhaps they were too frightened to show themselves. At any rate they were in no immediate danger. Doggie seemed perfectly content where he was.

That night was the longest that I have ever spent. The brute curled up at the foot of the tree and made himself comfortable and us uncomfortable. I groaned and shook my fist, but I did not descend.

In the morning I could see the boys emerging from the tents. They came straight towards us. I shouted a warning but they heeded it not. One of them whistled to the dog and with a friendly "Woof! Woof!" it bounded over to him.

The cook and I descended. The cook said he was sorry but he guessed he would look for work in town.

That morning my camping party started for home. The farmers demanded repayment in full—to take their boys away for so short a time was only an aggravation, they said. I did not argue the point. They seemed none to friendly as it was.

I will fight bravely for my country in time of peril, but never will I attempt to run a boy's camp. It is a job for a white hope.

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THE INDICTMENT

By RICHARD G. BERGER, M. I. T., '16

Ten million males must writhe and mangled die
In frantic frenzy fancied foes to slay,
A world of weeping women wonders why
Virility in man need pass away.

False glamor gone, deceived ones find instead
Of promised glory anguish, grief and pain;
Perfume of fields replaced by stench of dead
—And gory turned remorse of Cain.

Misguided breasts to wanton chests succumb,
To breed more males their patriotic aim;
To frenzied approbation that has come
What welfare needs to be the height of shame.

Ye moneyers who war have sanctified,
Whose avarice required that dupes should bleed,
Indicted stand for hellish homicide—
The massacre of fellowman for greed.

Ye sought more gold; and, covetous ye made
False diplomats renounce fraternal weal,
Then "duty" preached, to ignorance portrayed
The nobleness of strife for "martyred" zeal.

The innocents who fight are doomed to fail;
Their kind they slay without advantage, for
The blood and virtue gone does not avail,
But gloats and thrives the cursed cause of war.

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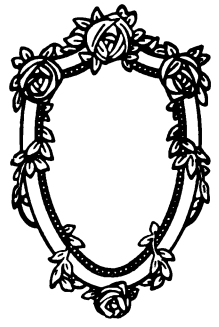
When jingoes clamor viciously and brand as cowards all
Whose ties to fellowman outweigh the gilded martial call
Determined say, "*Convinced of right I know not fear nor shame*
—Too well my country do I love, to murder in her name."



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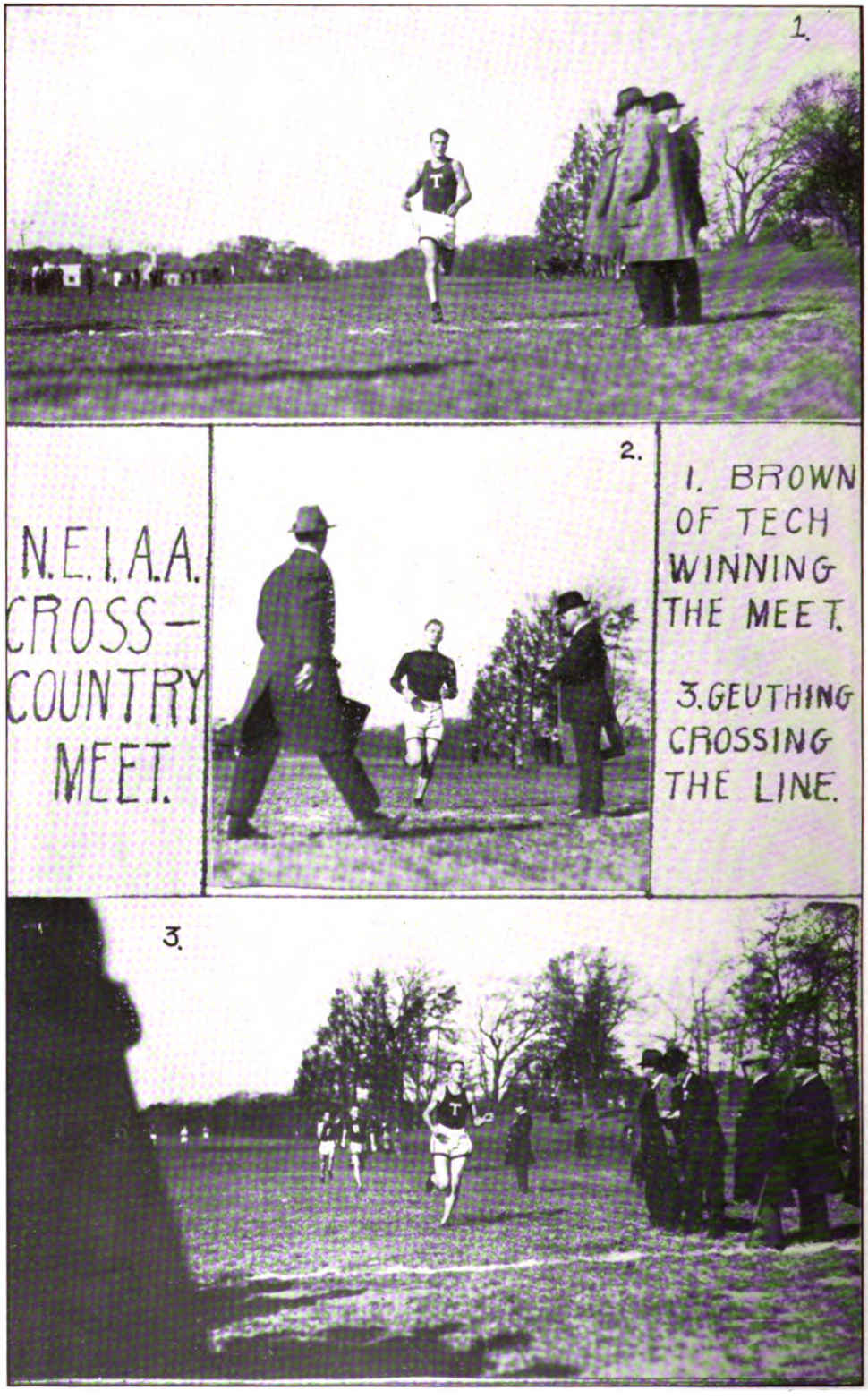

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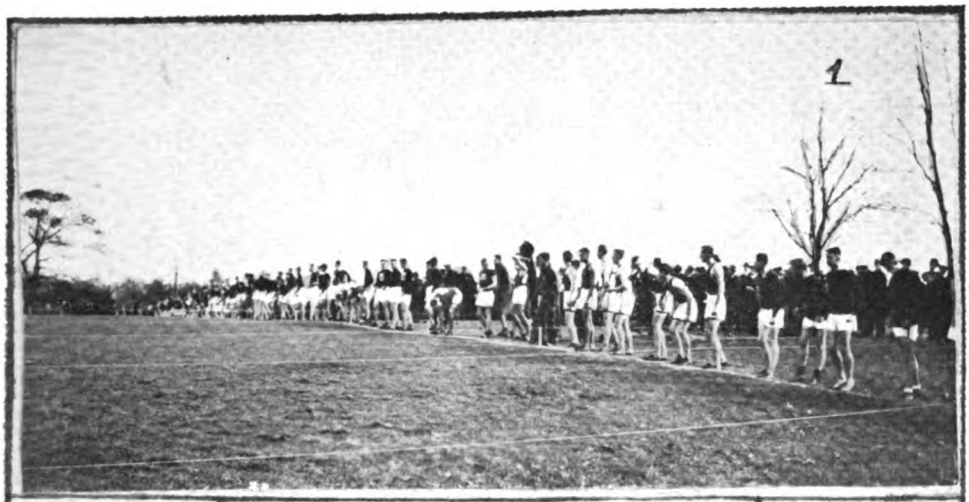

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1.
THE START

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THE
WINNER

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FACULTY HONORS

III

CHARLES R. CROSS

Appointed as a Member of the Advisory Board of the National Amateur Wireless Association

FEW who have endured that world-famed course in second year Physics, and emerged triumphant, realize that there is any more behind the scenes than appears on the lecture room table. The imagination is balked in its attempt to soar, and volplanes meekly to earth rather than measure its puny powers against the hidden terrors and monstrous difficulties which must face him who would dare venture beyond the first requirements of that redoubtable course.

Yet that much work is done within the bowels of the Walker building of which the student body is unaware, and honors granted for that work of which even the faculty is often ignorant is a truth to be impressed on the average student who holds the name and fame of Tech close to his heart.

For it frequently happens here as elsewhere that the prophet is not known in his home town, the truth of which Biblical observation is even now forced on us. Out from the west come accounts of an honor proffered a member of the Technology Faculty of which no Boston publication has as yet taken cognizance.

The honor comes to Professor Charles R. Cross, head of the Physics Department of the Institute. Professor Cross has been asked to act on the advisory board of the newly formed "National Amateur Wireless Association," of which Mr. Marconi is the founder and president, and Mr. J. Andrew White, of the Marconi Company, administrative officer. Other distinguished men who will serve on the board of advisers with Professor Cross are Major J. H. Elliott, Adjutant General of the Junior American Guard; Mr. C. E. Clayton, Professor Kennelly of Harvard and Technology, and Professor Sheldon of the Polytechnic Institute.

As for the purpose of the association, it represents, in the words of Mr. White, "the first movement for developing experimenters in an art which is of ever increasing importance to the world. The leading authorities in the country and the world's greatest expert in wireless communication have enthusiastically come to a hitherto unrecognized class of experimenters and offered to direct them in the acquisition of radio knowledge."

It is the view of the organizers that the amateur wireless operator should be encouraged, and the association plans to help young men in this field. Co-operation, coupled with direction of experimental work, is to be performed. Existing wireless clubs and organizations will be recognized and every amateur who is properly endorsed may join as an individual. Progressive courses of study will be placed in each member's hands, experiments

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far removed from text book humdrum will be added and a monthly bulletin of new calls and other items included It is pointed out that the United States in time of war would need hundreds of operators and these would be available. The importance of the movement is indicated by the number of distinguished men connected with it either in an active or advisory capacity.

While this may be regarded as a slight and unimportant acknowledgement of Professor Cross's work in this field, still it is indicative of the esteem in which that work is held, that he should be requested to act at the first formation of such a comprehensive plan.

Professor Cross's activity however has by no means been confined to this field of work. His interests extend from mountain climbing to the intricacies of musical pitch, although by far the greater portion of his work has been done in the field of electricity.

As Thayer Professor of Physics and Head of the Department of Physics, which post he has occupied since 1877, Professor Cross was instrumental in establishing at the Institute, Course VI, the first course in Electrical Engineering in the United States leading to a degree.

In 1893 Professor Cross was made chairman of the Electrical Congress of the Columbian Exposition. He is a member of the Physical Society, of the Astronomical and Physical Society, of the British Association, the French Physical Association and of other scientific societies and social bodies. Professor Cross was President of the Appalachian Mountain Club in 1880, and as a Fellow of the American Academy was Chairman of the Rumford Committee in 1904. He has contributed numerous papers to science, the best known being those on Telephony, Musical Pitch, the Electric Arc and the Phenomena of Audition.

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NOTES FROM THE RESEARCH DIVISION OF THE ELECTRICAL ENGINEERING DEPARTMENT

By ARTHUR E. KENNELLY, S. D., A. M.
Professor of Electrical Engineering at the Institute

Editor's Note. Professor Kennelly came to Technology under the new Harvard-Technology agreement which President Maclaurin has brought about. Many researches are being done under his guidance. His work may well be taken as the type of investigation which will continue under the new combination in the field of Electrical Engineering.

THE Electrical Engineering Department of the Institute, in combination with Harvard University, has a Research Division continuously occupied on electrical engineering researches, both experimental and economic. The Research Division is supported, at present, with the aid of temporary gifts from external sources, and, in particular, from the American Telephone and Telegraph Co. Other funds for particular researches have been donated from time to time. It is coming to be recognized by those who have the M. I. T. interests of engineering at heart, that institutions which undertake to teach technology must constantly apply themselves to learn, if they are to keep abreast of the knowledge of the time. To learn by research is to create both the atmosphere and the material for instruction.

EQUIPMENT

The Research Division has its office and laboratories in the Lowell Building. Some of the work, however, is carried on in Pierce Hall at Harvard, and also in a transformer house on the new Technology site.

In the Lowell Building is the artificial Power-Transmission Line, and the Alexanderson High-Frequency generator, with much apparatus of the Electrical Department. On the new Technology site is the Power-Transmission Span and Supporting Towers. At Harvard is the sound-excluding booth for acoustic experiments and much other Electrical Department apparatus.

THE ARTIFICIAL TRANSMISSION LINE

In order to ascertain experimentally the electrical conditions on an actual power-transmission line, perhaps hundreds of kilometers in length, it is desirable to construct an electrical laboratory model of the line, using coils of insulated wire interspersed with condensers. If the coils and condensers are carefully adjusted, the electrical condition of the artificial line, in regard to volts, amperes, ohms and watts, will then correspond to those on the actual imitated line under any assigned terminal loads.

The artificial line in the Lowell Building consists of 27 specially wound inductance units, each occupying a separate shelf or compartment, in a

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large case with sliding doors. Each unit corresponds to 48 km. (30 miles) of overhead copper conductor of 250 sq. mm. (500,000 circ. mils) cross-section; so that when all the coils are connected in series, they represent one of the three conductors of a transmission line extending over 1,300 km. (810 miles.) This line has the largest equivalent conductor cross-section of any yet constructed. Valuable technical researches have been made on this line, a few of which have been already published, and many more are yet to be made. A particular set of oscillograph curves recorded on this 1,300 km. line is shown in Figure 1. It will be seen that, with the distant or B-end of the line free, and with a 60-cycle alternating-current generator switched on at the near or A-end, the voltage at B did not begin to become noticeable until about 1-200 second later, and that the building up of the B-end voltage continued visibly for at least 3 cycles or 1-20th of a second.

The High-frequency Generator

For certain measurements with high-frequency alternating currents, an Alexanderson high-frequency generator has been loaned to the Department. When running at full speed, it generates 100,000 cycles per second. A photographic view of the machine is given in Figure 2. The direct-current 120-volt motor M drives the generator G through the speed increasing gear g, which has a ratio of 10 to 1. When the motor is running at 2000 r.p.m, it therefore drives the generator at 20,000 r.p.m. The peripheral speed of the rotor is 319 meters per second or 1,150 km. per hour; so that the rotor could roll over to Europe at such a speed in about 4 hours.

The Transmission Span on the New Technology Site

Through the generosity of Stone & Webster, who have presented the gift, the Institute possesses, at the new site in Cambridge, a transmission span of three power conductors suspended between two towers 150 meters apart. This is a replica, in mechanical details, of a standard span in the Big Creek line

Fig. 1
Building up of Distant-End Voltage on Artificial Lines

which transmits power, at 150 kilovolts pressure, from a hydraulic plant in the Sierra National Forest to Los Angeles, California, 400 km. (240 miles) away. Figure 3 shows one of the towers, the three power conductors, and the transformer house in Cambridge. A 15-kw., 100,000-volt transformer in this house enables tests to be made when a high voltage is applied to the line. Certain mechanical and electrical experiments are being conducted on this span, the results of which are not yet completed. Incidentally, the span has been found to make a very serviceable antenna for radio-telegraphy, and radio-telegraphic research has also been carried on in the transformer house at times when the span was not in use for high-tension tests.

Results of Recent Researches

A number of researches have already been made in the Division,

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some of which have been published after sufficient material and independent checks had been collected to make sure that the results were reliable. A few may be outlined here.

Experimental Researches on Skin Effect in Conductors

A conductor carrying an alternating current is well known to offer a greater resistance than it opposes to continuous currents; for the reason that the process of electrical conduction starts at the surface of the conductor, and soaks into the deeper strata. If the current is rapidly reversed, the condition is annulled and reversed before the soaking has penetrated very far. An alternating current of high frequency is thus carried by a mere superficial layer or skin of the conductor, the interior of which is virtually nonconducting under such treatment.

Researches carried on in the Division have shown,* that the established formulas for the skin effect on straight round wires, remote from other conductors, are reliable, at least as far as the frequency of 5,000 cycles per second. A number of measurements on the skin effect in strip conductors have also been recorded and published for the first time. Some of the results on strips were quite unexpected. The skin-effect resistance of strips is usually less than on round wires of the same cross-section; but is nevertheless much greater than has been generally supposed. These skin-effect researches are being extended in several directions, and are indicating results of great interest.

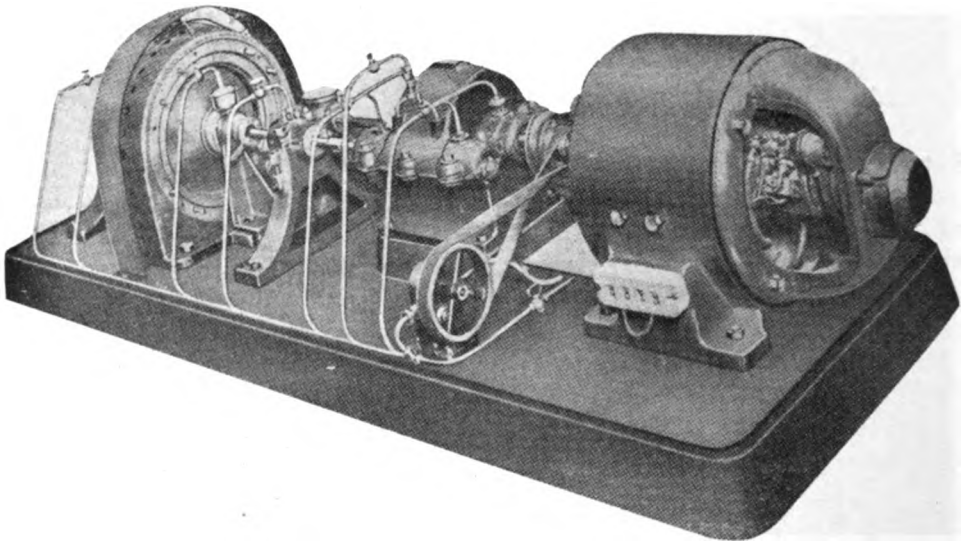

FIG. 2. MOTOR-DRIVEN HIGH-FREQUENCY GENERATOR

Relative Fields of Horse, Electric and Gasoline Trucks

As illustrative of an economic research carried on in the Division, is

*Proc. Am. Inst. Elec. Engrs., August, 1915 by A. E. Kennelly, F. A. Laws, & P. H. Pierce.

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one on the relative efficiencies and costs of horse, electric, and gasoline trucking* made under an appropriation by the Edison Electric Illuminating Co. of Boston. Figure 4 is taken from this report, and indicates the estimated cost of parcel delivery in cents per delivery, by horse, electric and gasoline wagon, respectively, over different radii in a delivery zone, as arrived at from records made in a number of American cities. It will be seen that the estimated cost is lowest by electric truck throughout all distances up to 10 miles (16 km.), except that at a radius of about 2 miles (3.2 km.), the horse wagon appeared to be about equal in cost to the electric wagon. Beyond a radius of about 9 miles (14.5 km.), the horse wagon becomes the most expensive of the three vehicles.

Explorations of Telephonic Diaphragms

A telephone receiver diaphragm vibrates under the electromagnetic action of the telephonic currents carried over the line wires. The amplitude of the vibration is ordinarily very minute. Prior to the reseaches conducted in the Division, the vibration seems only to have been measured at one point of the diaphragm's surface, usually the center. An instrument called a "vibration explorer," was designed and constructed, which enabled the amplitude of vibration to be measured all over the surface, whether the diaphragm was actuated acoustically, or electromagnetically. The diaphragms were found to vibrate in their first mode of motion; or to and fro, as a whole. In acoustic excitation, the amplitude was greatest at the center; but in electromagnetic excitation, for the case investigated, the amplitude was greatest over one of the receiver poles*. This research is being continued.

Delivery and Handling of Miscellaneous Freight at the Boston Freight Terminals

A research on the important economic question of the movement of

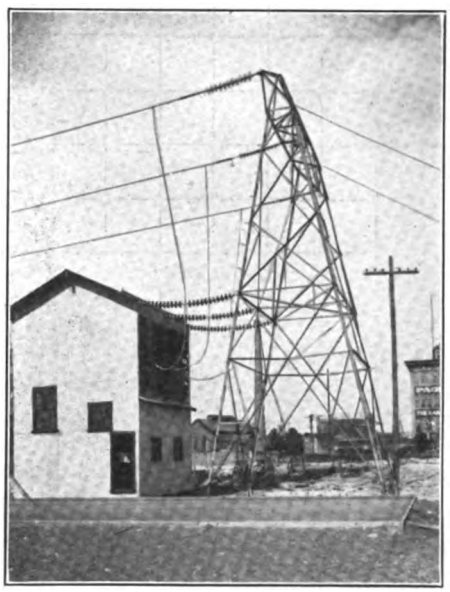

Fig. 3
Transmission Tower at the New Technology Site

freight at railroad terminals in Boston, was conducted in the Division during the years 1912-13, under an appropriation from two railroad companies. Records were made of the time expended in the trucking of freight between the railroad terminal and the warehouses, of receipt or delivery,

*Vehicle Research Bulletin No. 4, by Harry F. Thomson, Research Division, August, 1914.

*"Explorations over the Vibrating Surfaces of Telephonic Diaphragms under Simple Impressed Tones," by A. E. Kennelly and H. O. Taylor, Proc. Am. Phil. Soc. April, 1915. M. I. T. E. E. Res. Bulletin No. 7.

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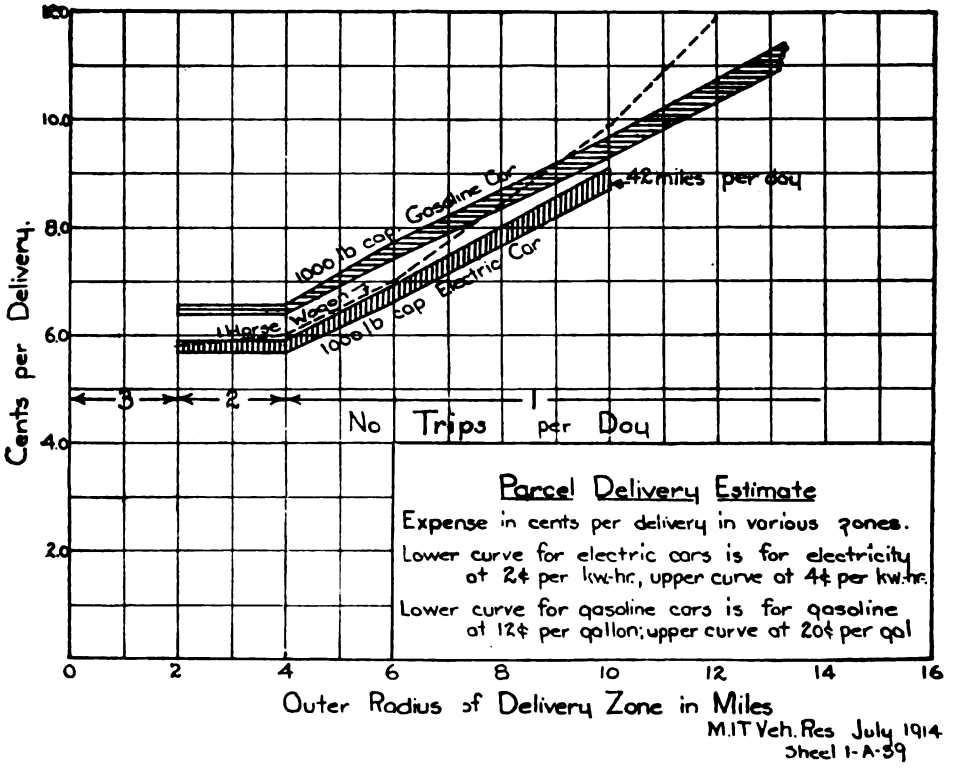

FIG. 4. PLOT OF PARCEL-DELIVERY ESTIMATES

with a view to ascertaining what average share of time were consumed in the work of a wagon engaged in freight hauling in the city of Boston. Figure 5 shows the analysis of daily wagon performance, as spent in the railroad yard, at the warehouse, and on the street, respectively*.

Street-Railway Traffic Counts

Another example of research in the economics of traction, undertaken in the Division, is found in an investigation made in 1914, on passenger "traffic counts" on the street railways of Boston; under an appropriation from various companies interested in electric traction. A chart was made** showing the passenger movement on a particular car journey between Hyde Square and Park Street, Boston. This shows where the passengers entered and left the car, and the condition as to occupancy at all points along the journey. By making a number of such observations on different trips and car routes, much valuable information can be gathered as to the working of a street-railway system.

Vail Library

The Institute is in possession of a very fine electrical engineering library, of over 20,000 volumes, presented by Mr. Theodore N. Vail, and known as the Vail library, which is also allowed

*Fig. 2 of Bulletin No. 5. "The Delivery and Handling of Miscellaneous Freight at the Boston Freight Terminals," by Harold Pender, H. F. Thomson and C. P. Eldred, Feb. 1914.

**From "Recent Practice in Traffic Counts," by D. J. McGrath, Electric Railway Journal, pp. 1385-1386, December 26th, 1914.

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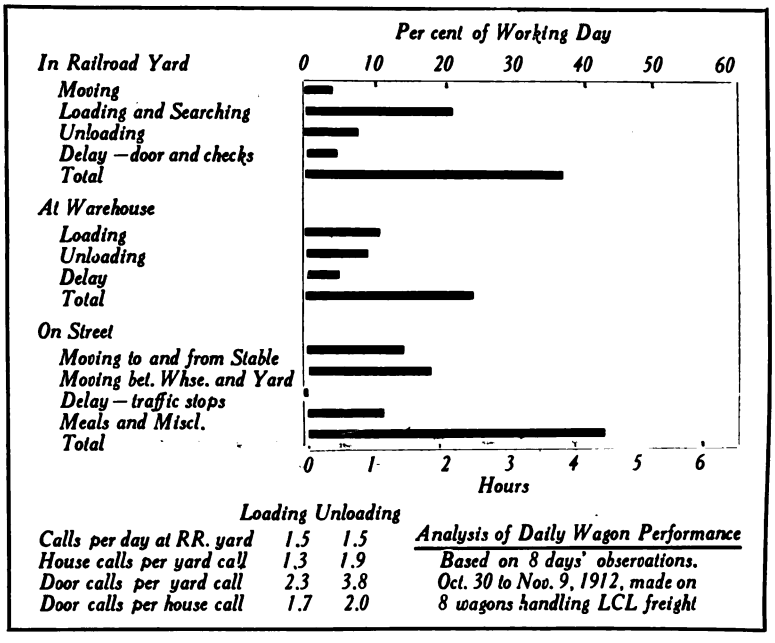

FIG. 5. ANALYSIS OF DAILY WAGON PERFORMANCE

an appropriation by the American Telephone and Telegraph Co., for cataloguing and extension. This work has been carried on under the Division. It is hoped to have the catalogues completed by the Autumn of 1916, after the date at which the Institute expects to open its new buildings in Cambridge.

Organization and Meetings

The Research Division is controlled by a Research Committee of the Electrical Engineering Department Staff, and is in charge of an executive committee consisting of Professors C. A. Adams, D. C. Jackson and A. E. Kennelly. Its Secretary is Mr. O. R. Schurig. Its staff comprises an associate, six assistants, and one reearch librarian.

Meetings of the Division are held on the first Wednesday in each month during the academic year, although the work of the Division covers the entire year. To these meetings graduate and senior students are invited. They are usually attended by the electrical engineering department staff, and by visitors. At these meetings the conditions of the various researches are described by the assistants engaged on them, thus bringing the most recent developments to notice, and eliciting discussion as to the best future method of procedure. These discussions have proved very interesting and instructive to all present. They are open to all persons connected with the Institute.

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CHESS: A NEGLECTED STUDY

By ALFRED N. PRAY, M. I. T., '18

AMONG the non-academic activities which occupy the college student's time, athletics play an important, perhaps a dominant part. This diversion of interest is encouraged by the approval of the faculty as well as by the student's inclination, being considered advisable from the standpoint of health and general welfare. Indeed, professor and student are led toward a complacent attitude as they contemplate the well-balanced routine of the college man; study and exercise appear to them to comprise a rounded whole, a comparatively perfect mode of life. On the other hand Chess, king of indoor games, is in a measure denied place in the scheme of things both by faculty and students; seemingly because it is considered a superfluous activity as well as a dangerous rival to the work of the curriculum. In this dismissal of Chess as a useless distraction the effects of overhasty judgment are, at least to the chess-player, discernible.

It is conceded generally that the true value of schooling lies less in the facts learned than in the mental training acquired by the act of learning. Little development of the mind is needed in order to retain and apply dry formulae to determinate propositions; but when indeterminate problems of a nature foreign to one's experience are confronted, the innate resources of the mind are taxed to their utmost. Mental training renders these resources accessible and produces the tactile mind, able to cope with emergencies. Unfortunately, studies by their nature tend to degenerate into sets of formulae, and the progress of education is marked by a constant, often a losing, warfare against routine and rote. This trouble is the educator's constant topic; and one might suppose that the effort to overcome it would be accompanied by a search for an activity or study providing relief from classroom work as well as the mental discipline necessary for real education. Such a search may well have been instituted; yet the chess-player may aver that a promising field has been overlooked.

Chess-play combines the principles of a science with the processes of an art. The body of the science is determinate; it may be learned like any other study. The application of the art is necessary because of the infinite variety of the chess-board, whereby every position is to be considered a separate problem; and skill in the art comes, as in other arts, through innate ability and practice. In this connection we may liken the chess-player to the army commander-in-chief. The army leader, like the chess-player, has as his guide definite principles of action; but in practice the indeterminate movements and intentions of his foe render these principles useless unless subordinated to other considerations, i. e., those of the art of warfare. This is the reason a commander-in-chief is necessarily a person gifted with more than ordinary ability, and sometimes a superior genius. Fine chessplay in like manner requires the exercise of skill be-

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fore that of knowledge; and conversely the practice of chess tends to develop ingenuity and originality. A study whose theories are applied under conditions requiring a constant use of invention and critical judgment must be accorded a cultural value comparable with that of academic studies.

Were Chess not the finest of games, it might have attained estimation as the most salutary of studies. That it is a source of pleasure needs no further proof than the number of its devoted "fans." Chess possesses in a high degree that attribute especially characterizing games, of inducing the player unconsciously to exert his utmost ingenuity in a contest of wits. The premise of a battle, with elements of chance removed in the outcome, is one which has appealed to lovers of pure sport ever since "Chaturanga" was played on the banks of the Ganges. Perhaps this quality of the game has led the educator, on a survival of the principle that "what we like is not good for us" to look askance on Chess. However, this neglect of the diversion of Napoleon and Frederic has come about, it deserves better treatment. Without recommending that Chess be played as a life employment, it may be maintained that this game has elements which render its study of unique value; far from apprehending an immediate decline in scholarship in connection with the spread of chess in colleges, we may surmise that a few more chess-players would mean better students. For, just as athletics owe their success in culture of the body to the athlete's pleasure in the task, so Chess is successful as "athletics for the mind" because of the enjoyment occasioned by its practice. Neither the failure nor the shirk among students is attracted by Chess.

It may not come amiss to indicate a few minor, yet still important, qualities of the game of Chess, in comparison (merely for convenience' sake) with its doughty rivals, the field sports. However much energy the young man may afford for the wear of shoe-soles on the cinder-track, most of us at a more advanced age must give up the delightful pursuit of the stop-watch. Chess is an eternal stand-by; skill once acquired remains as long as the intellect, last stronghold of the ego, is intact. Should this fact not appeal to us a fundamental one, another of more immediate and commanding interest may be cited. Financially, the field sports require a solid backing; so much so, that even at Technology, the hundreds of dollars poured into their support by college activities prove meagre, and must be supplemented by a poll-tax. Chess-play needs practically no financial support. If proof of this were asked, it is to be found in the fact that, under existing conditions, Chess is played at this Institute, with even a certain degree of enthusiasm.

We intend, then, to work for an increase in Chess interest at Technology. If some think prosperity will injure the sport which stands adversity so well, we fail to share their apprehensions.

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CLASSIFICATION OF THE SQUEEK IN THE JOINT BETWEEN THE FIRST AND SECOND PODERMERES OF THE THIRD MAXILLIPED OF THE POTAMOPIA PALLIPES OR CRANKY CRAWFISH

A HUMOROUS THESIS READ BEFORE THE PEPTONE CLUB

By PAUL H. DUFF, M. I. T., '16

SQUEEKS have played an important role in the development of civilization and may be said to range from the inaudible to the squeeks called the "music of the spheres," also inaudible. Therefore, it is fitting and proper that a research for the ultimate attainment be put forth under the cover of impenetrable altruism before the appoplecticism of so great a truth be left undescribed for the education of science in her future development.

Naturally, before we can proceed with greater elucidation of detail, a definition of terms becomes imminent. 1st. *Squeek* comes from the old English Sqeek or Squeke meaning to squeek. 2nd. *Podomere* is derived from the Sandscrit word for baby carriage. 3rd. *Maxilliped* has a rather touching ontogany, being called after Max Keezer the third sattelite of Saturn. The derivation of *Potemobia pallipes* is so painfully evident that we will leave it to the imagination of the reader. The technicality of the word *crawfish,* however, is worthy of some commiseration. *Crawfish* may have been, botanically speaking, originally in the same tribe as crayfish. The crawfish was first described by Socrates in his sonnets to the Sauropoda.

The crawfish was known in England as early as the third century A. D., when King Alfred is said to have dropped one in the Danish King's coffee as he sat at breakfast.

Having now made thoroughly cloudy and unobtrusive the terminology of this metameric research, we will proceed to make an equally obscure description of the apparatus induced.

The maxilliped or leg was inclosed in a glass bulb in which was a perfect vacuum consisting of compressed Platinum gas (at a pressure of 132-11 pounds per square inch). Every third one of the hairs which cover the podomeres was insulated with CO_2 snow. Then roentgen rays, infra violet and ultra red rays were passed through the bulb. This wave motion caused the joint to be alternately flexed and bent. A steel needle, which had been passed through the end of the leg, registered the vibrations caused by the squeeking in the joint by the following device: the end of a cable made up of many infinitesimal strands of selenium was brought

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near the needle. The needle vibrating across the ends of the strands caused signals to operate upon Boston Common. These signals were pyrogenic masterpieces, so that the amount and kind of squeek could be determined by integrating the rocketts, roman candles and pinwheels set off and differentiating the sum to the base determined by dividing the number of green fires by the number of red fires. When the joint got to squeeking in good style, which was on December 12th, the common looked very pretty, like one of the rings in Pluto's circus.

Fearing that this would become noticeable to the public, a different line of work was considered advisable. While the change in plans necessitated no small inconvenience the scope of our work was broadened thereby and the science of nut-hausing advanced in leaps and bounds.

Experiments were made on many animals in the open country, such as the zoo at Franklin Park, in a bootless endeavor to reproduce the squeek in question. We found that the bark of a dog was quite unlike what we were after, but the cooing of the American eagle approached more nearly. Only once was the squeek ever exactly reproduced. That was when a giraffe whose sire had once been bitten by a crawfish scratched his nigh horn with his off hind hoof, the other three feet (a yard in all) being firmly placed on igneous rock. At this point we ran into difficulties because we could find no more igneous rock this side of the Charles, all the rock hereabouts being aqueous in collaboration. Besides, the giraffe died when we had gone no further in our experiments upon him than to cut off his tail just behind his ears. This unfortunate debility on the part of the subject caused us to abandon field work and again to betake our efforts to the laboratory.

At this point, in the research I experienced an idea. If other diseases are caused by germs, why not squeeks? Pursuing this line of inductive reasoning, we instituted a search with a specially constructed concave-mirror infra-microscope. We were rewarded as we deserved. There in the joint we could see groups of organisms smaller than had ever been seen by man. This *bacillus squeekinus* apparently is very nervously constituted, and it squeeks when scared. Indeed, the slightest motion in the joint unnerved them to such an extent that they would grit their teeth in such a manner as to cause the observed squeek. These bacilli grow munificently on a nutrient medium made from the third distillate of an oily serum taken from the foramen between the odontoid process of the Tse-tse flee's humerus and the coroid coat of the sternum. This liquid must be titrated against a stone wall and made perfectly placid with apamorphine.

We were now in a position to adjust and classify our squeek. The squeek was determined to be of the axle-greese type so skillfully adulterated as to easily nolpros execution under the food and drug act. The squeek is of the magnitude of one wheel squeek x $11^{36.7}$, and it is estimated that it could have been heard by a green plant of the paleolithic age with the aid of chloroform.

This research has had at least two far reaching results. Cultures of the bacillus squeekinus were dropped over the allied trenches from Zeppelins during a thunderstorm. The electric waves so affected the bacalli that they all gritted their teeth, causing high pitch vibrations, which although inaudible affiicted the French with dumb hydrophobia, while

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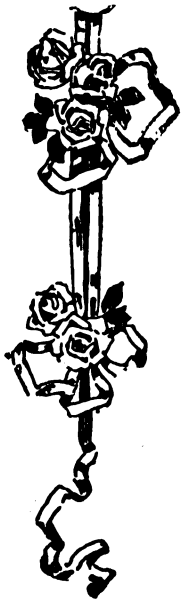
the other allies succumbed to an epedemic of shakeless paralisis agitano.

The other ramification had an entirely accidental paleontology; a gypsy moth finding its way into the bulb during the electric experiments, got some CO_2 snow on its fur. Upon being exposed to long wave lengths, it secreted a coat of a hard substance which upon chemical analysis and tests for strength and brittleness, was discovered to be simply a mixture of plaster of paris and portland cement. The knowledge of this fact is of inestimable value in tree surgery.



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AN IMPROVED ZINC-LEAD PIGMENT

Bp EDWARD C. HOLTON, M. I. T., '88
Chief Chemist, The Sherwin-Williams Co.

Editor's Note. One of the greatest inspirations which we receive at Technology is improving industrial conditions and processes. Mr. Holton here describes a great step that has been done in this direction. The new pigment cannot help but be of interest to every one connected with engineering.

IN this country we produce from the ore, with or without prior roasting, four classes of white pigments.

Of these zinc white produced by the Wetherill process from oxide, carbonate and silicate ores free from lead, is nearly pure zinc oxide. The slight impurities present consist of small particles of unconsumed coal, ashes and ore dust mechanically carried over, and sulphur combined as sulphide, sulphite and sulphate. Traces of arsenic in various forms may be present. The sulphur and arsenic usually come from the coal in which they are almost invariably present. In brief, the Wetherill process consists in mixing an oxide ore (sulphides must first be roasted) with carbon, (anthracite coal usually), and heating in a furnace on a bed of glowing coal to a temperature of 1000° Centigrade. The zinc oxide is reduced to metallic zinc which vaporizes. The metallic vapors coming into contact with an excess of air above the fire combine with oxygen, forming white clouds of zinc oxide, Zinc White. These white fumes are carried along with the products of combustion through a series of settling chambers and cooling pipes to a bag house in which cloth filters are used to separate the gases from the pigment. Mechanical draft is necessary for the proper burning of the charge and also for the transport of the pigment fumes from the furnace to the bag house. Coarse particles of dust from coal, ore and ashes collect in the settling chambers. The filters which separate the gasses from the pigment are usually cloth bags about two feet in diameter and thirty or more feet in length suspended vertically. The pigment which collects in the bags is shaken down usually by hand every two or three hours. The burning of a charge usually requires about six hours. The furnaces are arranged in blocks and charged and discharged in rotation so that the process is continuous. The construction and operation of the Wetherill furnace is described in detail by Ingalls in the Metallurgy of Zinc and Cadmium.

If a zinc ore containing a little lead is treated by the Wetherill process with such modifications as may be necessary, there is produced a white

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pigment containing a little lead usually in the form of lead sulphate or basic lead sulphate. Such a pigment is termed "Leaded Zinc Oxide." *Metallurgical and Chemical Engineering,* September 15, 1915, describes in detail the operation of a plant to produce such a pigment.

When a lead sulphide ore is introduced into a coke fire under proper conditions, vaporization and oxidation take place with the production of a third type of white fumed pigment termed Sublimed Lead. This pigment consists mainly of basic sulphate of lead with a lesser amount, five per cent. to fifteen per cent. of zinc oxide. This process is described by Hughes in the *Journal of the Society of Chemical Industry,* 1909.

The difficulty has been that the ore deposits of zinc free from lead are comparatively rare while the deposits of mixed sulphides of lead and zinc are many. Until quite recently it was impossible to advantageously separate some of these mixed ores.

With a view to utilizing some of these low grade mixed ores by converting them into a pigment, the erected a plant in the gas belt at Coffeyville, Kansas, in the year 1906. The process employed is a modified Wetherill process and has been described in a general way by E. W. Buskett in the *Mining and Engineering World,* July 8, 1911. White fume pigments in which zinc oxide predominates and the lead sulphate is greater than five per cent are usually termed Zinc-Leads. The pigment made at the Ozark Smelting and Mining Company Coffeyville plant of the Ozark Smelting & Mining Co. is a Zinc-Lead consisting of about 65 per cent. pinc oxide and 35 per cent. lead sulphate.

ROASTING THE SULPHIDE ORES

The process is as follows: Mixed sulphide ores containing the desired ratio of lead and zinc are crushed, sampled and roasted. The roasted

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ores are then treated by a modified Wetherill process already mentioned and the pigment produced is known as Ozlo White. Until recently the white fume pigments have generally been used without subjection to any treatment after collection in the bag house. Occasionally they have been heated to remove moisture and adhering gases.

Since the mixed lead and zinc ores frequently contain many elements in small quantities, traces of these various elements are found in the resulting pigment. Gaseous sulphur dioxide and carbon dioxide are present in varying amount as well as water soluble salts. These impurities are generally small and almost negligible, yet it occasionally happens that difficulties are encountered in the use of these pigments in paint. Some of these impurities may cause undue thickening in the mixer when the vehicles are being added or an unsatisfactory consistency may ensue in the mill. Some of the impurities may react with the driers used causing a loss of siccative power to such an extent that the paint may not dry satisfactorily. To avoid any possible trouble of this sort which might occasionally arise and to provide a pigment of uniformly good qualities, the Ozark Smelting and Mining Co. have installed a process for the further treatment of their pigment after it leaves the bag house.

THE COFFEYVILLE, KANSAS, PLANT

As a result of many experiments it has been found that pigments possessing some of the undesirable properties mentioned may be stabilized and greatly improved, besides being made more uniform, by subjecting them to a process of wetting, washing and drying. By this process of wetting and washing, opportunity is given for the chemically active substance to react forming more stable compounds and at the same time

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the greater part of the water soluble constituents present after the reaction passes away in the wash water.

The wetting and washing is effected in an apparatus designed for the washing of barytes. The pigment is trammed from the bag house to a wooden mixing tub provided with a mechanical stirrer and is thoroughly agitated with clear water which has been filtered through sand filters and is metered as used. From the mixing tub the pulp is pumped to the washers, first entering the distributing cup. The washers consist of three lead lined steel tanks, the upper part of each being cylindrical, ten feet in diameter and ten feet in height, the lower part being an inverted cone nine feet in depth. Inside the tank is suspended a wooden tube eight feet in diameter and nine feet in length. Near the top of the inner wooden tube is an overflow pipe through which the wash waters escape. Above each tank is a distributing cup from which the pigment suspended in water is fed into the annular space between the tank walls and the wooden tube. The wash waters flow down the annular space to the bottom of the inner tube and then rise therein to the discharge pipe. The flow of the liquid is slow and the pigment moves more rapidly, settling away from it and sliding down the sides of the cone to an outlet at the bottom whence it is elevated through a pipe by means of injected water to the top of the second washer and in like manner to a third. Each washer is set on a level four feet lower than the one preceeding it.

The pulp finally obtained from the bottom of the last washer is pumped to settling tanks and after settling to a consistency of about 50 per cent solids, it is pumped to the dryer by centrifugal pumps.

The results obtained by this process can be readily summarized. In a month of thirty-one days, one set of three washers treated 1,375,750 pounds of pigment in 279 hours of actual operation with a water consumption of 929,400 gallons. In this same time one dryer in 674 hours of actual operation dried 1,224,650 pounds. In this month's run, it is estimated that 126,000 pounds remained in the system and there was a loss of 25,100 pounds of which a certain part was actual loss due to floating off of suspended particles and substances dissolved. A part of the apparent loss is due to the less moisture content of the dried pigment. The loss due to floating away of suspended particles is less than one-half of one per cent.

The washers and the dryer, which latter has been fully described in *Metallurgical and Chemical Engineering* April, 1915, are the invention of Wm. R. Macklind, and are protected by patents.

Ozlo White may be readily mixed with linseed oil to form an excellent white paint which possesses high covering power and great durability, or it may be used in combination with other white pigments or with colored pigments as may be desired. The individual particles are very fine, like those of the other white fume pigments. Its specific gravity is about 5.75, while that of zinc oxide is 5.45, sublimed basic sulphate of lead 6.33 and Dutch Process White Lead 6.38. (Amer. Soc. Test. Materials, 1913).

The tinting strengths of these pigments are in the following order: Zinc Oxide, Ozlo White, Dutch Process White Lead and Basic Sulphate of Lead.

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In producing Ozlo White the manufacturers are not only conserving some of our country's mineral resources, but are furnishing to the paint industry so desirable a pigment that the capacity of the plant, which was doubled some time ago, is again being largely increased.

EMPTYING-ENDS OF THE BAG FILTERS

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A Magazine devoted to the interests of the Massachusetts Institute of Technology--The Official Organ of the Association of Harvard Engineers

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F. M. BARNICOAT, '19

General Offices of the Publication, 42 Trinity Place, Boston, Mass.

Secretary of the Association of Harvard Engineers, 218 Pierce Hall, Cambridge, Mass.

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All manuscripts submitted for publication in the TECHNOLOGY MONTHLY AND HARVARD ENGINEERING JOURNAL should be accompanied by the writer's full name and address. Manuscripts not accepted for publication will be returned only if the author so requests. Photographs, drawings, etc., will be returned to the contributor immediately after publication.

Forms close the 28th of the month immediately preceding date of publication. Material specially arranged for may be received up to the fifth day following.

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EDITORIAL

WHERE THE SYSTEM IS AT FAULT

THE present day condition of things as they exist is by no means perfect. Some things we believe to be good and proper, others to be the contrary. One of the places where a glaring defect has been recently exposed is in student voting at general elections.

When the time came for registration this fall several Tech and Harvard students went to their proper registration booths in order to be able to vote at the general elections this November. Among the numerous questions asked was: "Are you self-supporting?" The percentage of students at either Tech or Harvard who receive no financial aid from parents or guardians is negligibly small. They did not lie about it. Hence they were denied the privilege of registering, therefore or voting.

To be classed with lunatics and the feeble-minded is hard enough to one's sensibility. To be a student at an institution which is noted the world over as demanding higher intelligence of its pupils than any other engineering school in the country, and to be told that your opinion of state and city candidates for office, and their platforms, is not as good as the most ignorant foreigner, who knows only enough to be naturalized as a citizen, simply because you are not a self-supporting student, is an outright insult.

When Thomas Jefferson declared, "All men are created free and equal," on which most of our political structure is built, he by no means meant that at the age of twenty-one the laborer was an intellectual peer either of the mechanic, or much less the professional man (in which class the Tech man would naturally fall). Jefferson's equality of man before the law ends with the law. The professional man's judgment of candidates and platforms at an election will always be far more valuable than that of the laborer, and any system that debars a man of the Technology type from voting simply because of not being, during his student years, self-supporting is seriously at fault.

PUT YOUR EGGS IN ONE BASKET

THE cry for the versatile man has often been heard. Many-sidedness, the full rounded man, the man of broad culture, how often have these been pointed out to us as the types we must approximate to pass the mile posts on the road to the highest success. For the versatile man all of us feel a certain meed of respect, and even perhaps envy, without knowing just how these feelings came into being. Have we ever questioned them closely enough, have we ever sought to analyze them?

Immediately as we seek our eyes turn towards the past. Who has not exclaimed in wonder at the vast accomplishment of Michelangelo, that colossus in painting, sculpture, and architecture; at Da Vinci, painter incomparable, engineer, scientist; at Cellini, master goldsmith, sculptor, warrior, literateur; at Goethe, poet, scientist, author and philosopher, and at a multitude of others

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whom history records from Empedokles to our Benjamin Franklin. And who has not felt his own powers slight and puny by comparison? Yet the list by no means begins or stops with these. There are a host more of brilliantly versatile men in our own national history alone, and they are with us even today.

But the versatile man is the exception; and in these days he is a greater exception than ever before. As ages are counted it was but yesterday when a man could know all the science it was possible to learn. Today just to conceive of such a man, or even one who is fully acquainted with any one branch of science, is impossible. The fund of human knowledge has become far too great for any one man to assimilate—the day of the specialist has come.

But, the objection is raised, we said the versatile man is still with us. True. That is just where the rub comes. The exceptional man will be many-sided no matter where he is put or where he is born — you cannot hold him down. The mistake is in training the mediocre man to many-sidedness. He is not strengthened but weakened. He becomes a jack of all trades and a master of none, and nine times out of ten he ends up as a dilletante if he has money, and a failure if he hasn't—the nuance here being mostly in phraseology.

So for the ordinary man it may well be questioned whether an attempt at broad culture is not a mistake. As a specialist he can follow one line of work, and if he follows it consistently and conscientiously, not necessarily brilliantly, he can hardly fail to "arrive." Hedda Gabler says that she married Tesman because, well, "Tesman is a specialist, my dear sir," and he was not "In any way ridiculous." But Tesman was ridiculous. Ibsen painted him the fool with all the grim power of his satiric pen, and yet Ibsen could not deny the fact that this type, simple, slow, plodding, unspectacular as it is, the specialist as an almost devitalized man, is the type which accomplishes things and which reaches the heights in any particular profession. Germany has recognized this. Her pre-eminence above other nations in the fields of science and especially in chemistry is due not to her overwhelming number of geniuses but to the industry of her plodders, men who were willing and able to stick to one thing until they attained success.

The way of the plodder is the surest way for the average man, his most certain path to success. Not the showy acquirement of many accomplishments, but the concentration in one line of endeavor. More than that it is the path for the exceptional man also. The man who in the final analysis is the man of versatile mind and many-sided accomplishment is often the man who has started in the way of the plodder and who has followed his every endeavor to its single success. Take the men prominent in our national life today—Edison, Ford, Wilson, Hill—specialists, all of them. And if they are not engaged just now in the work for which they trained it is because they first gained their balance and power of judgment—in other words their versatility—by their application to one thing and their mastery of that thing. But again the exceptions. Not the ordinary man.

And yet these exceptions were produced in the school of the ordinary man. Out of their one-sidedness grew their many-sidedness; out of their singleness of purpose evolved their wide usefullness; out of their unity of endeavor came their many accomplishments. "Do not put all your eggs in one basket" is a proverb which may well be questioned. Better is it to trust in the homely maxim: "Put all your eggs in one basket, and—WATCH THAT BASKET!"

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HARVARD GRADUATE NOTES

'97—E. M. Moses is with the Boston Bridge Works, East Cambridge, Mass.

'99—John Ware is with the Hugh Nawn Constructing Co., Boston, Mass.

'03—Dean G. Edwards is chief engineer with the Intercontinental Construction Corporation, Brooklyn, N. Y.

'04—W. E. Belcher is consulting engineer for the Westinghouse, Church Kerr Co., New York City.

'06—Walter F. Barklage has the position as manager with the Sanitary Sales Service Co. of St. Louis, Mo.

'07—Robert D. Thomson is with the General Electric Co., Lynn, Mass.

'08—Carlisle W. Burton and Mason T. Rogers, under the firm name of M. T. Rogers & Co., with offices at 810 Iroquois Building, Buffalo, N. Y., are sales agents for automobile supplies.

'08—Edward L. Lincoln is industrial engineer with the S. D. Warren Co. at Cumberland Mills, Me.

'09—Walter S. Weeks, formerly instructor in the Mining Department, is now instructor in the University of California, Berkeley, Cal.

'10—Gustaf S. Bohlin is with the Interstate Commerce Commission, Boston, Mass.

'10—William W. Pagon is with Lerner & Whitman, Consulting Engineers, Fidelity Building, Baltimore, Md.

'13—Thomas Buel is with the Imperial Oil Co., Toronto, Can. His address in Toronto is 254 Jarvis St.

'13—Andrew Y. Hodgdon is in the Construction Department of the firm of Stone & Webster, Boston.

'13—George H. Hazelhurst has returned from his work with the Harvard Red Cross Unit which has been stationed in Servia for the past six months.

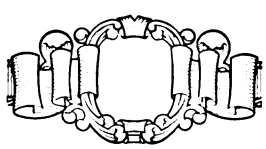
'13—William H. Capen was married on September 15th to Miss Julia R. Schmalz, Wellesley, '14. Their address is 115 Washington Place, New York City.

'14—Edward G. Sheibley is with the Southwestern Portland Cement Co., El Paso, Texas.

'14—L. W. Weed is with the Turner Construction Co., 11 Broadway, N. Y. City.

'15—Thayer Francis is with the Saco-Lowell Machine Shops, Lowell, Mass. His present address in Lowell is 56 Kirk Street.

Dr. J. W. M. Bunker, formerly Assistant in the Department of Sanitary Engineering is now director of the Department of Bacteriology of the Digestive Ferments Co. of Detroit, Mich.



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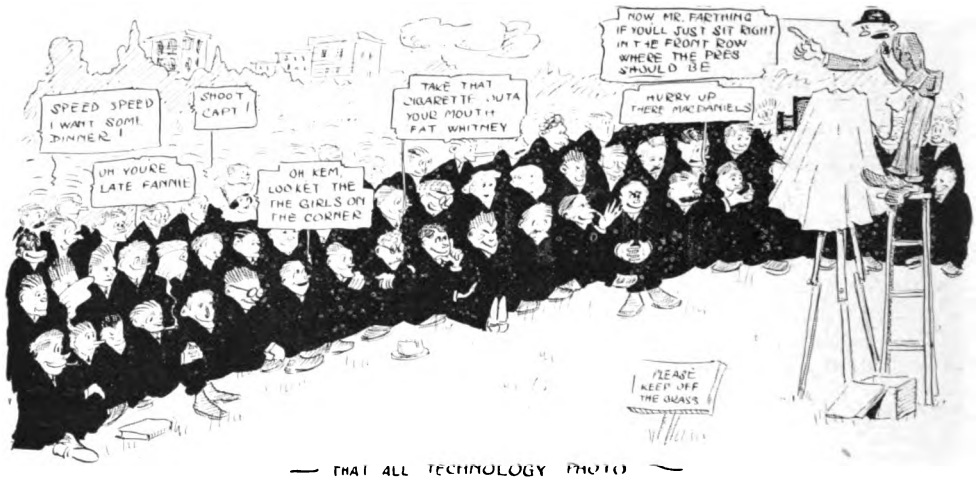
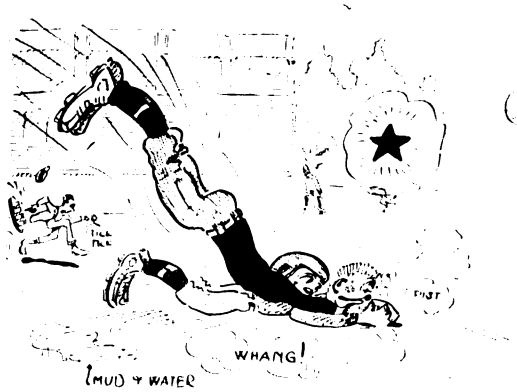


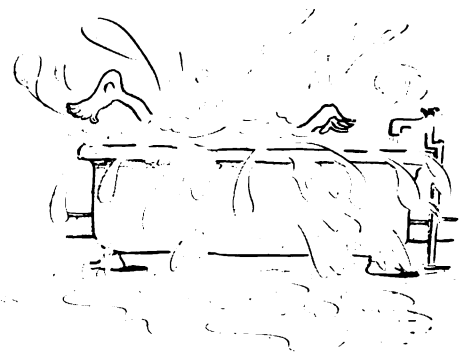
— THAT ALL TECHNOLOGY PHOTO —

AHA ! WE HEAR OUR FAIR CLEOFANS GAVE A REGULAR DANCE

THE MUSICAL CLUBS RECENTLY GAVE A CONCERT AT THE FRANKLIN SQUARE HOUSE, FOLLOWED BY A DANCE - AND — —!



TECH ARTS .. HAW-VARD ARTS 0 - 0
OLD CAPT COLLEARY MADE SOME TACKLE ON HIS 8 YARD LINE AND SAVED TECH



SWIMMING CANDIDATES SHOULD TRY DON PARKINSON'S SCHEME - HOME PRACTICE IN THE BATH TUB

"A LIL' A THIS AND A LIL" A THAT"

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"UNIONS"

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LYRIC WRITERS MUSIC COMP°SERS SCENERY DABERS AD CHASERS

— EVERY °NE'S W°RKIN' HARD F°R THE TECH SH°W —

— THE SENI°R DINNER —

WHAT'S THE MATTER WITH °UR SENI°R CLASS?

IT'S ALL RIGHT!

L F van Zelm
1918

THE LONG AND SHORT OF IT AT DRILL

WHY WAS IT FOUR MEMBERS °F THE MUSICAL CLUBS MISSED THE LAST TRAIN AFTER THE WHEATON CONCERT? WE MIGHT AND - WHEATON IS A GIRLS C°LLEGE

DOIN'S OF THE MONTH

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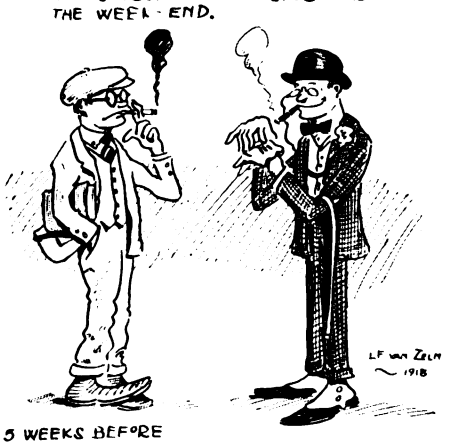
AN' HE WAS SAVING THOSE COPPERS FOR XMAS — ONLY A WEEK OFF!

JUST THE DREAM OF A FELLOW WHO COULDN'T GET A GIRL FOR THE WEEK-END.

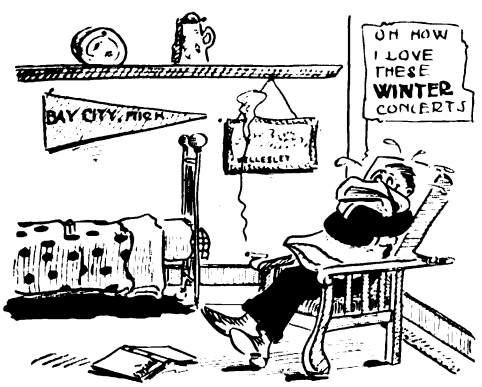
WELL, I WONDER WHO WILL HAVE THE BEST GIRL AT THE CONCERT



5 WEEKS BEFORE THE WINTER CONCERT

1 WEEK BEFORE.

WHAT A DIFFERENCE A GIRL WILL MAKE!



GETTING IN TRAINING FOR THE HOUSE PARTIES

PLENTY OF CORRESPONDING THESE DAYS.

GETTING READY FOR THE WINTER CONCERT AND SO FORTH

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LOCAL COLOR

First man—I see most of the Tech fellows are raising very small mustaches. The style I suppose.

Second man—No, that isn't the reason.

(Hint. Probably the same reason why a bald headed man doesn't grow hair.)

SWIFT MATRIMONY.

First Stage Hand—"What was the row out front during the first scene, Bill?"

Second Stage Hand—"The understudy nurse-maid got excited and carried in the heroine's baby when it wasn't due to appear until three years later in the fourth act."—Punch Bowl.

Prof.—"Can any gentleman tell me the question of the moment?"

Voice (in anguish)—"What time is it."—Princeton Tiger.

Prof. Brush—How do you spell bird-cage?

Hansum Harry—B-i-r-d-dash-c-a-g-e.

Prof. B.—Where is the dash in bird cage?

H. H.—That's what the bird sits on.

She—"What did you call bachelors?"

He—"Men who have contemplated matrimony."—Springfield Student.

Freshman trying to get out of drill.

Colonel—Do you know how to take orders?

Fresh—Why yes, I worked in a grocery store last summer.

Prof. Caldwell finds peach 12 inches in circumference.—Daily Nebraskan.

We know of several that are larger than that.—Augwan.

Aw go on is right.

"Is he a stude?"

"No."

"Why are you so sure?"

"Oh, I was in his room. There is no September Morn picture there. No copy of Snappy Stories. He has no House Rules hanging on the wall. There were several copies of the Literary Digest and no ash trays. What more do you want?"—Penn State Froth.

The workman was digging.

The wayfarer of the inquisitive turn of mind stopped for a moment to look on. "My man," said the wayfarer at length, "what are you digging for?"

The workman looked up.

"Money," he replied.

"Money!" ejaculated the amazed wayfarer. "And when do you expect to strike it?"

"Saturday," replied the workman, and resumed operations.—Lampoon.

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PRESS DAY.

"Let me print a kiss upon your lips?"
She nodded her sweet permission.
We started to press, and I rather guess
We printed a full edition.

"But one edition is not enough,"
She said, with a charming pout;
So again in the press the forms we placed,
And we got several extras out.

—Williams Purple Cow.

Officer—"Why, what's the matter with this? That's excellent soup."

Private—"Yes, sir—that's what we saz, sir."

Officer—"Very well, then. What's the complaint?"

Private—"It ain't the soup, sir; it's the cook. 'E calls it stew."—Punch.

HOW OLD IS ANNE?

Bishop (visiting country parish in Ireland)—Who lives here Dennis?"

Parishioner—Och, shure it's Mr. O'Brien, but he's dead.

"And what did he die of, Dennis?"

"Faith and died of a Thuresday."

"And how long has he been dead?"

"Shure, your Riv'rence, if he'd lived 'til tomorrow he'd been dead a fortnight."—Medley.

Dear Coach:

I am a freshman 7 ft. 3 in. tall and weigh 119 lbs. bare. Could I play on your team?

E. Z. Tulerne.

Dear Prospect:

The call for goal posts has not been issued yet. Yours,

Running Brooke, Coach.—Ex.

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Deer Edytur:

Havin seed yur poastul askin fer Fawl Hoomor I wud rite yu sum reel gud stuff becawz whut youv bin hevin laitly aint no gud. The reesun Fawl is cald iz cuz then the leevz fall, and aftur whilé pepul slip on the ise and fawl. Also the prisus on strau hatz begin 2 fawl, and yu kin bi tenis shooz cheeper. I awlso here yur futbal teem iz goin 2 Fawl rivr. this iz the peeriud fer fawlin straz and fawlin outer bed. The other da the teechur sed spelin wuz fawlty —i ges thats got sumpin to do with fawl maybe.

Your ardunt fawl-ower.
Spring wintur Sumerautum.

—Pennsylvania Punch Bowl.

AN AMATEUR

Polly—He doesn't know anything about the little niceties of paying attention to a girl.

Dolly—Why, I saw him tying your shoestring!

Polly—Yes; but he tied it in a double knot, so it wouldn't come undone again. —Judge.

According to a recent account from a Western daily, a celebrated vocalist narrowly escaped with his life in a train wreck; but that night, continues the article, he was able to appear in three pieces.—Pennsylvania Punch Bowl.

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HOW ABOUT A HATRACK

"Gentlemen," remarked the professor, "the general function of the heads of several learned members of this class is to keep their neckties from slipping off."—Lampoon.

ANTI CLIMAX.

Mable—When John called last night he gave me a ring.

May—Oh, did he?

Mable—Of course. How else would I have known he was at the door?—Ex.

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The New
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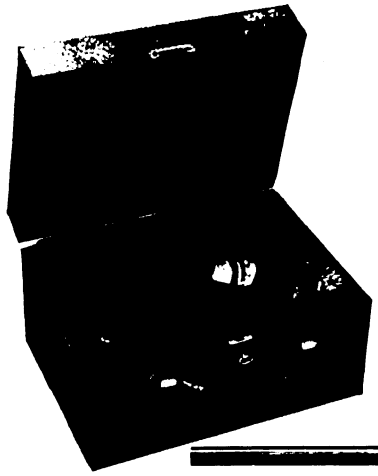
Portable Electrodynamometer Instruments
Model 341 A. C. and D. C. Voltmeter



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For complete information regarding Model 341 write for Bulletin No. 2004. Other Models in this group are Model 370 A. C. and D. C. Portable Ammeter described in Bulletin 2003; Model 310 Single-Phase and Direct Current Portable Wattmeter and Model 329 Portable Polyphase Wattmeter, both described in Bulletin No. 2002.

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A Cockney philosopher in London has recently observed that if you take God out of "gold" you'll have "'ell."—Ex.

REMODELED

Prof. (to fat man who has been absent)—Well, Smith, I'm glad to see you're back.

Student in rear—That's all that I can see.—Ex.

"I wonder if Adam could have had any poetic talents?"

"Of course not. Poets are born, not made."—Ex.

Even a tightwad sometimes gives himself away.—The Springfield Student.

Fresh—I was out in Jack's motor last night. He has everything in it, even a pedometer.

Soph—You mean speedometer, old man. A pedometer is an instrument for measuring how far you walk.

Fresh—(doggedly)—All right, I'll stick to pedometer.—Pennsylvania Punch Bowl.

I know no one who knows no one, no one whom no one knows and no one knows I know no one, no wonder, I suppose.—Pennsylvania Punch Bowl.

"This looks like a foreign letter from the front."

"Well, turn it over and see what it looks like from the back."—Lampoon.

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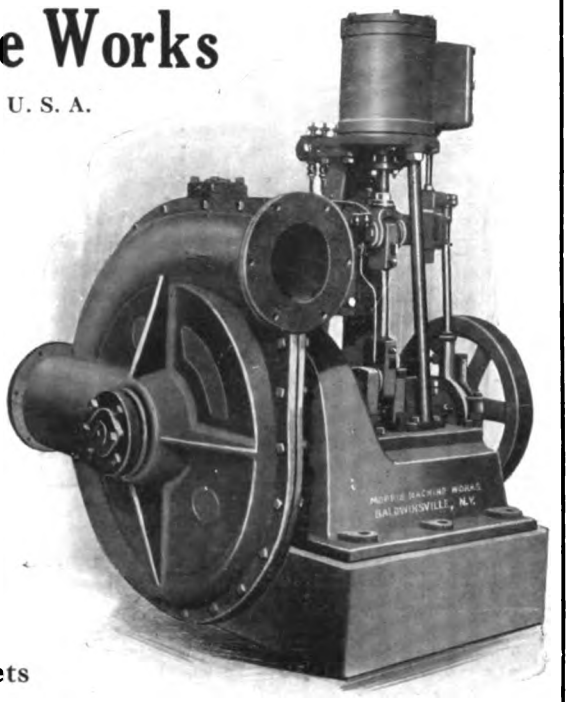

COLOSSAL IGNORANCE

Fair Fair-Visitor—Can you tell me why the State exhibits are all closed on Sundays?

Gruff Guide—Well, I should say so. Don't you know that the States belong to the Union?—Chaparral.

A marriage notice between Jane Lemon and Ebenezer Sweet was thusly announced in the "Painted Post Dispatch":

How happily extremes do meet,
Twixt Jane and Ebenezer.
She was sour, but now she's Sweet,
And he's a Lemon-squeezer.
—Punch Bowl.

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THE CHIMES

When eventide barks softly o'er the hills
Upon Cayuga's scented rocks and rills.
'Tis then my harrowed spirit fills with rimes
As I listen to the music of the chimes.

And e'en at one o'clock when class is o'er
And hungry Youth from out the class-rooms pour;
'Tis then, O LUNCH: of all the other times
I listen to the music of the chimes.

But when at eight A. M. the jingles roar,
I curl myself between the sheets and snore,
My last night's mouth a-tasting gin and limes,
I quiver at the music of those....damn bells.—Cornell Widow.

The host—It's beginning to rain; you'd better stay to dinner.

The guest—Oh, thanks very much; but it's not bad enough for that.—Siren.

One (offering cigar box containing three cigars)—"Have a cigar."

Two (taking one)—"Thank you."

One (about to take one himself)—"Take the other, too."

Two (putting the other two in his pocket)—"Thanks."—Siren.

Hazel—I see you played in the game last Saturday.

Harold—Yes, that was my initial performance.

Hazel (enthusiastically)—Congratulations on winning your letter!—Lampoon.

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When a college man gets a letter from home, he knows that it contains one of two things, a check or "Hell."—Jester.

She—What made the tower of Pisa lean?

He—It was built in an age of famine. —Lampoon.

"Did you see those autos skid?"

"Sir! How dare you call me that?"

—Puppet.

Father—I shall not remit the check you asked for!

Son—I shall never forget your unremitting kindness!—Ex.

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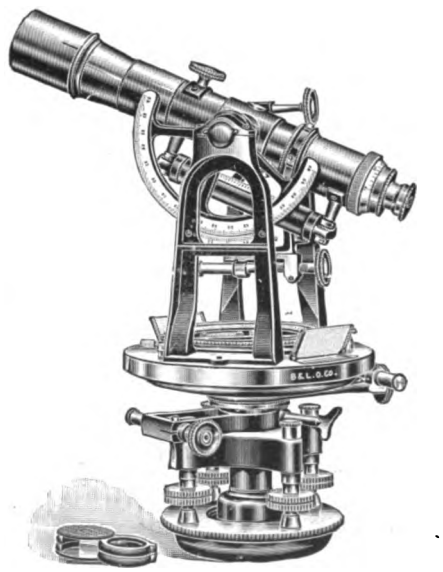

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CHRISTMAS CARDS in exclusive designs now displayed on our counters.

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"Dog-gone it," said Rastus, as he laid a freshly stolen turkey on his beloved's back doorstep, "Ah'm goin' to win this gurl by fair means or fowl."—Pennsylvania Punch Bowl.

Eloise—You have made a great impression upon me.

Eloitus—I'm so sorry. I'll not hold you so tightly next time—Yale Record.

WHEN YOU ROOM TOGETHER.

"I can't say I like your new tooth paste."

"That's shaving cream."—Yale Record.

She—An apple a day keeps the doctor away.

He—Don't stop there; an onion a day keeps everybody away.—Ex.

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Feb. 1916 Vol. II, No. 7

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A magazine devoted to the interests of the Massachusetts Institute of Technology—The Official Organ of the Association of Harvard Engineers

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Entered as second-class matter at the post office, at Boston, Mass. Published monthly during the college year by the students of the Massachusetts Institute of Technology. Publication office, Technology Union Building, 42 Trinity Place, Boston. Harvard Editorial Office, 218 Pierce Building, Cambridge, Mass.

Mail Address: Technology Monthly, M. I. T., Boston, Mass.
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Subscription rate, $1.50 per year; 25c. per copy. Advertising rates upon application

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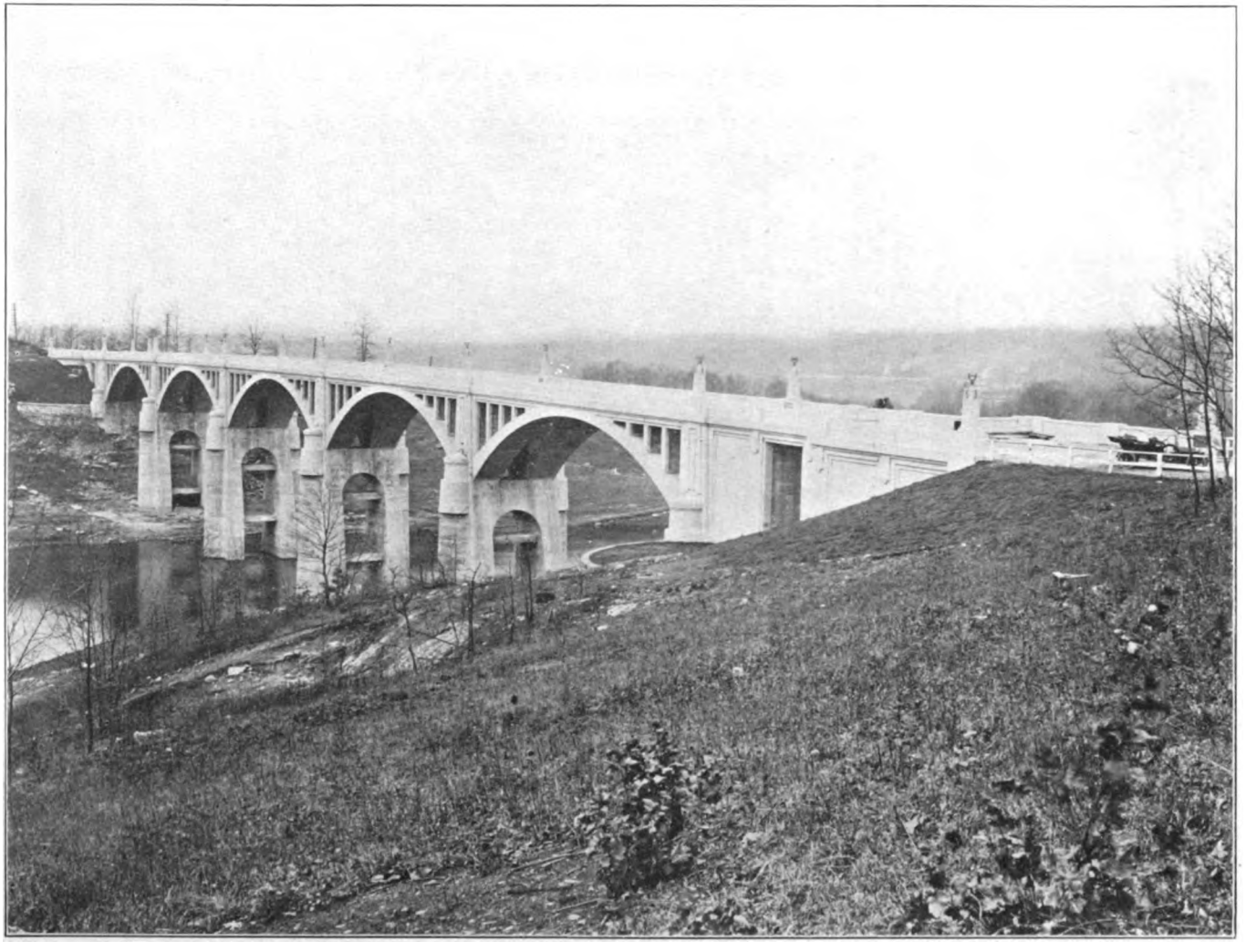

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This bridge carries a relocated highway across a branch of Kensiko Reservoir. It has five reinforced concrete arches of 127 feet span. The central piers are approximately 100 feet high. The water will rise to the springing lines of the arches.

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THE TECHNOLOGY MONTHLY
AND HARVARD ENGINEERING JOURNAL

VOL. II BOSTON, MASS., FEBRUARY, 1916 NO. 7

CORRELATION BETWEEN TENSILE AND BENDING TESTS OF CAST IRON

By WINSLOW H. HERSCHEL, H.U., '06

Assistant Physicist with the Bureau of Standards

Editor's Note. One of the greatest services of research is to save time and expense in the making of tests. And tests, both physical and chemical, are of the utmost importance in our civilization. It is to be regretted that more such relations as Mr. Herschel here derives have not been found. This is the first part of his paper, the second appearing in the March issue.

TWO variables are said to be correlated when one of them is, to a greater or less extent, a function of the other. This subject has been very extensively developed by biologists[1] and economists[2], but has been neglected by engineers, although equally applicable to their problems.

We have chosen as an illustration a series of tests made on cast iron test bars as adopted by the American Society for Testing Materials, Sept. 1, 1905. The arbitration test bar for gray iron castings should be 1¼-inch diameter at one end, and 1 3-16 inches at the other, with a length of 12 inches between supports. The diameter of the bars tested by the author actually varied from 1.21 to 1.28 inches at the section of fracture, but the apparent diameter depends to such an extent upon the thoroughness with which the rough castings are cleaned of sand, that no attempt will be made to allow for variations in diameter.

(1) See Statistical Methods, with special reference to biological variation, by C. B. Davenport.
(2) Frequency Curves and Correlation, by W. P. Elderton. Published for the Institute of Actuaries, by Chas. and Edwin Layton, London.

It is the usual practice to make bending tests, observing the center load and the deflection at the moment of rupture, and then to turn tensile test pieces, if they are required, from parts of the broken bars. As the tensile tests are expensive, it is desirable to find an equation connecting tensile strength with center load or with deflection, whichever of these quantities should prove to give the better indication of the tensile strength. In other words, we wish to predict the tensile strength from the results of bending tests, with as great a probability of correctness as possible.

The degree to which variations in one variable depend on variations in another is measured by the coefficient of correlation[3], r, which is given by the equation

$$r = \frac{\Sigma\, d_x d_y}{N\, \sigma_x \sigma_y} = \frac{p}{\sigma_x \sigma_y} \qquad (1)$$

where N is the number of pairs of related values of the variables X and Y. d_x and d_y are deviations from the mean, that is, if M_x and M_y are the arithmetic

(3) W. I. King, Elements of Statistical Method, p. 199.

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means of X and Y respectively, $d_x = X - M_x$ and $d_y = Y - M_y$.

$$\sigma_x = \sqrt{\frac{\Sigma (d_x)^2}{N}} \quad \text{and} \quad \sigma_y = \sqrt{\frac{\Sigma (d_y)^2}{N}}$$

σ (with suitable subscript) is known as the standard deviation, and should not be confused with another common measure of dispertion, the mean deviation, which is the arithmetic mean of the deviations from the average, taken without regard to their sign. In the case of the standard deviation, the + and — signs are eliminated by squaring.

Table 1 gives data for determining the coefficient of correlation from 13 tests of cupola iron.

TABLE I

Test No.	X = Tensile Strength lbs. per sq. inch	dx = Deviation of X from average	2 Y = (dx) center load, lbs. / 10000	dy = Deviation of Y from average	(dy) 2 / 10000	dx dy
1	28,210	—4340	1884	3200	—600	36	+ 260
2	29,400	—3150	992	3600	—200	4	+ 630
3	29,960	—2590	671	3400	—400	16	+1036
4	30,930	—1620	262	3700	—100	1	+ 162
5	31,200	—1350	182	3600	—200	4	+ 270
6	32,050	— 500	25	3600	—200	4	+ 100
7	32,120	— 430	18	3500	—300	9	+ 129
8	32,730	+ 180	3	3800	0	0	0
9	32,850	+ 300	9	4200	+400	16	+ 120
10	35,030	+2480	615	4100	+300	9	+ 744
11	35,810	+3260	1063	4200	+400	16	+1304
12	36,000	+3450	1190	4200	+600	36	+2070
13	36,870	+4320	1866	3800	0	0	0
Totals			8780			151	+9169

The average tensile strength was found to be 32,551 pounds per square inch, or say $M_x = 32{,}550$, while the average load was calculated as 3762 pounds and M_y taken as 3800 to simplify the arithmetical work. We have then for the standard deviation of tensile strength

$$\sigma_x = \sqrt{\frac{87{,}800{,}000}{13}}$$

$= 2600$, and for the center load,

$$\sigma_y = \sqrt{\frac{1{,}510{,}000}{13}}$$

$= 341$. Then by equation (1)

$$r = \frac{+\ 9{,}169{,}000}{13 \times 341 \times 2600} = +0.796$$

To judge the significance of this value, we must find the "probable error"[4], which is equal to

$$\frac{0.674489\ (1 - r^2)}{\sqrt{N}} \qquad (2)$$

Substituting the value of r in equation (2), we find that the probable error is 0.0683, so that r is 11.65 times the probable error. Hence we have a clear case of correlation, the rule being that the existence of correlation is a practical certainty if r is more than 6 times the probable error.

Using the same 13 tests as in Table I, we may next find, with the help of Table II, the correlation between tensile strength and maximum deflection. Here M_y was taken as 0.110 in. The standard deviation for tensile strength, σx remains 2600 as before, and we find the new standard deviation for deflection

$$\sigma_y = \sqrt{\frac{0.001701}{13}} = 0.01145$$

$$\text{Then } r = \frac{159.9}{13 \times 2600 \times 0.01145} = 0.413$$

which is only 2.66 times the probable error, so that there is no certain indication of correlation. The same thing is shown graphically by plotting deflection against tensile strength. It would be difficult to decide from the points in Fig. 2 whether deflection increased or decreased with an increase in tensile strength. On the other hand,

TABLE II

Test No.	Y = Deflection inches.	dy = Deviation of Y from average.	10,000 (dy) 2	dx from Table I	dx dy
1	0.100	—0.010	1.00	—4340	+43.4
2	.098	— .012	1.44	—3150	+37.8
3	.128	+ .018	3.24	—2590	—46.6
4	.110	0	0	—1620	0
5	.101	.009	0.81	—1350	+12.1
6	.110	0	0	— 500	0
7	.106	— .004	0.16	— 430	+ 1.7
8	.094	— .016	2.56	+ 180	— 2.9
9	.100	— .010	1.00	+ 300	— 3.0
10	.124	+ .014	1.96	+2480	+34.7
11	.128	+ .018	3.24	+3260	+58.7
12	.122	+ .012	1.44	+3450	+41.3
13	.106	— .004	0.16	+4320	—17.3
Totals			17.01		+229.7
					— 69.8
					+159.9

(4) G. U. Yule. An Introduction to the Theory ot Statistics, p. 352.

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it is evident from Fig. 1 that the load necessary to produce rupture increases with the tensile strength.

Nagle[5] has considered the relation between tensile and bending tests of cast iron bars, 2 by 1 by 24 inches. He found that 175 out of 217 specimens had a tensile strength between 20,000 and 30,000 lbs. with an average of 23,732 lbs. per sq. in., the average breaking load of transverse bars being 2,383 lbs., giving a ratio of tensile strength to breaking load of 9.96 to 1. The average deflection was 0.45 in.

If R is the modulus of rupture, or stress per sq. in. of extreme fibre, we have (on the supposition that the formula $M=\frac{SI}{C}$ holds good up to the breaking point) $R=S=\frac{Mc}{I}=\frac{6Pl}{4bd^2}$ (3). Substituting the values for the dimensions of the bar, equation (3) becomes

$$\frac{S}{P}=\frac{24x6}{4x2x1x1}=18$$

Nagle quotes D. K. Clark's Engineers' Tables for the formula

$$\frac{S}{P}=\frac{1}{1.155bd^2}$$

which would give in our case S/P=10.4 which agrees fairly well with Nagle's experimental value of 9.96. That equation (3) should give correct results is not to be expected. As pointed out by Merriman[6] "the modulus of rupture derived from the static formula does not agree with the tensile or compressive strength of the material, but this in no wise reflects on the truth of the formula whose theory supposes that the elastic limit is not exceeded" It should also be noted that the theory assumes that the modulus of elasticity is the same in compression and in tension, and that the neutral axis is consequently at the center of gravity of the cross section. This is not the case for cast iron. Burr[7] calls the modulus of rupture, R, an "empirical quantity," and says, "no great error will be involved if R is taken at twice the ultimate tensile resistance for square bars, and two and a quarter times the same quantity for bars with circular section."

On this basis we should have for our rectangular bars (assuming they may be considered "square") $R/P=\frac{S}{2P}=9$ to check Nagle's value of 9.96. For our circular bars, on the other hand, equation (3) becomes

$$\frac{R}{P}=\frac{12x32}{4\pi\,(1.25)^3}=15.6,$$

while on Burr's basis of R=2.25 S we have R/P=6.93. Nagle's conclusion that the breaking load should be multiplied by 8, in the case of bars of circular section, to obtain the approximate tensile strength, has little weight because based on too small a number of observations. From the tests of Table I, we have on the average, S=32,551 and P=3,762, or S/P=8.65, so that R=1.8 S which agrees more nearly with Burr's ratio for square than for round bars. Our value, however, is based on only 13 tests.

The method which we have used in Tables I and II becomes too cumbersome when applied to a large number of observations such as are necessary in order to be able to draw reliable conclusions. To illustrate the more usual short cut method for handling a large number of observations, we shall take a series of 175 tests on air furnace iron containing about 10 per cent of steel. The variations in per cent of carbon and sulphur were 2.65 to 3.54 and 0.040 to 0.078 respectively. All tests in which blow holes or chill balls appeared in either bending or tensile tests are omitted. Considerable difficulty was experienced at first in getting good test bars poured after the casting was made, as the small amount of metal remaining in the crane ladle cooled rapidly. The trouble was finally remedied by pouring

(5) A. F. Nagle, Proceedings A. S. M. E., 1909, p. 1057.
(6) M. Merriman, Resistance of Materials, p. 13.
(7) W. H. Burr, Elasticity and Resistance of the Materials of Engineering.

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directly from the crane ladle into the mold without the use of a hand ladle The taking of bars before and after the casting is made, is supposed to guarantee that the temperature at which the casting is poured will be between the temperature of the two sets of bars. Actually, the first set of bars, being cast from a hand ladle, gives no indication of the temperature at which the main casting was poured. The metal cools off in the hand ladle much more rapidly than in the crane ladle, and if the foundryman thinks the metal too hot, he pours his test bars and then waits till the large ladle cools off before pouring the main casting. It would be a rash inspector who would object to this procedure. But with the second set of test bars, poured after the casting is made, there is a certainty that the temperature will not be higher than that of the main casting, and this set is therefore more valuable than the first, and should not be dispensed with.

The first step in dealing with a large number of observations is to separate the values of the variables into groups or classes, each group having a certain range or class interval. This class interval should be as large as possible, provided that we may treat all the values assigned to any one class, without serious error, as if they were equal to its middle value. As a general rule, the number of classes should lie between 15 and 25, and the middle value of a class should preferably have a small number of significant figures. After selecting the class intervals, the next step is to make out a correlation table showing the frequency with which each class occurs.

Table III is such a table showing the relation between center load and tensile strength of air furnace iron, the classes being designated by their middle values. In each row, up to the 17th, the lower numbers are the frequencies, the total frequencies, f, for each row being given in col. 22, and the total frequencies for the columns being similarly given in row 19. In one test the center load was 3,400 and the tensile strength 24,650 lbs., and this is accordingly indicated by a 1 in the upper left had corner of the table, row 1, col. 1, being the only test in the first row, of the 3,400 lb. class, and the only test in the first column, of the 25,000 lb. per sq. in. class. 28 of the 175 tests had a tensile strength between 38,500 and 39,490, which is shown by the 28 in col. 15, row 19, and of these 28, seven occurred when the breaking load was 4,200 lbs., as shown by the 7 in col. 15, row 9, which is the largest frequency in the table.

In order to deal with small numbers, and thus simplify the numerical work, averages of X and Y are assumed equal to the middle value of some class interval, and a class interval is taken as the unit in calculating moments. Thus 4,100 is assumed to be the approximate average center load, as indicated by the heavy lines in row 8, and differences from this value, using the class interval of 100 lbs. as a unit of measurement, are given in col. 23. d_y' signifies the deviation of Y from an assumed average. For example, class 3,400 is at a distance of $\frac{3,400-4,100}{100}=-7$ class intervals from the origin, the -7 being recorded in row 1, col. 23. Similarly, taking 37,000 as the approximate average tensile strength, class 25,000 is at a distance of $\frac{25,000-37,000}{1,000}=-12$ class intervals from the origin, which is indicated by the -12 in col. 1, row 20. Multiplying -7 by -12 gives +84 which is the upper number in col. 1, row 1. These upper numbers in rows No. 1 to 17 are called the deviation products, and are used to determine the mean product, p, of all pairs of associat-

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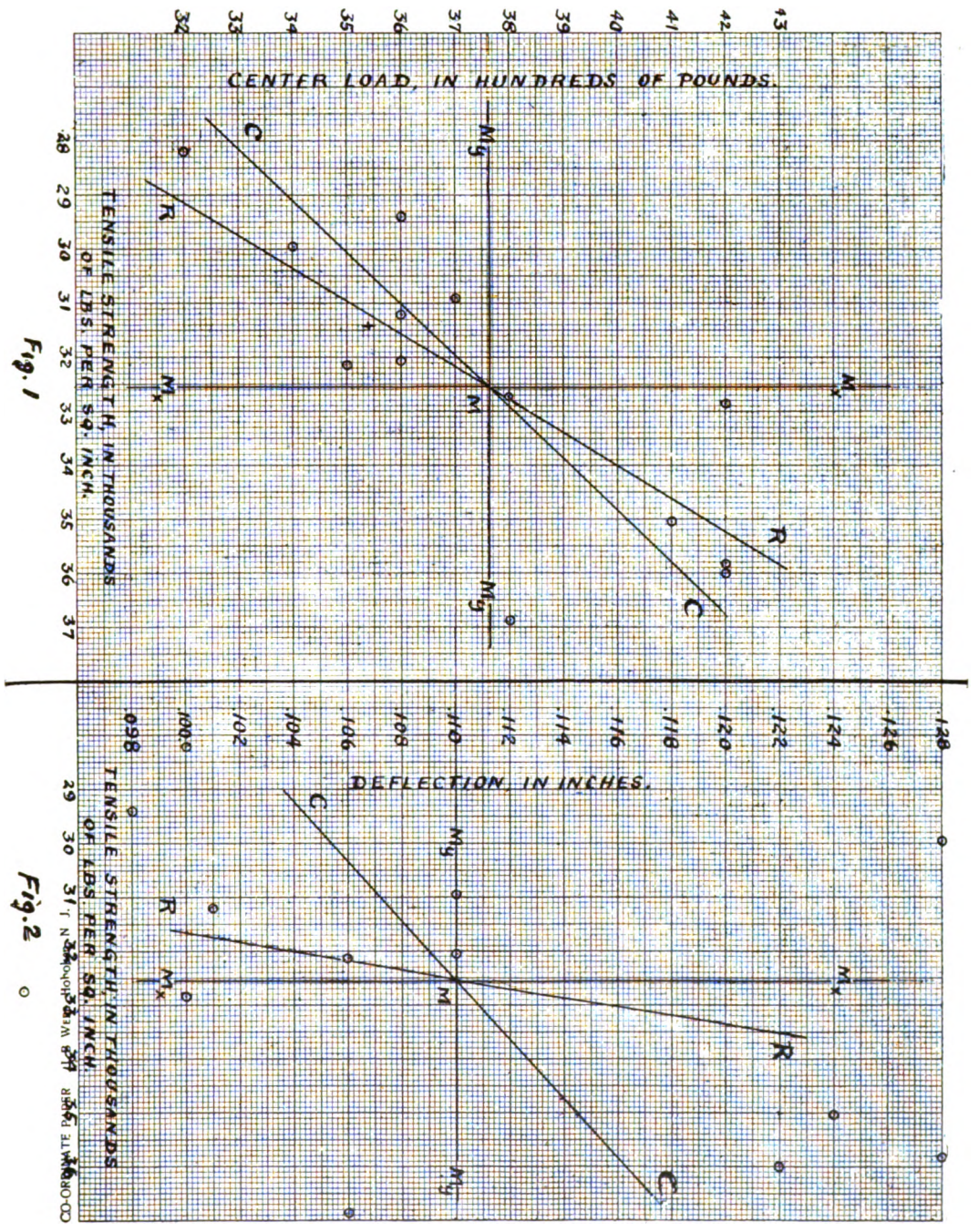
CENTER LOAD, IN HUNDREDS OF POUNDS.
TENSILE STRENGTH IN THOUSANDS OF LBS. PER SQ. INCH.
DEFLECTION, IN INCHES.
TENSILE STRENGTH IN THOUSANDS OF LBS. PER SQ. INCH.
C
R
M
Mx
My

Fig. 1

Fig. 2

TABLE III

x = Tensile Strength, in thousands of lbs. per sqare inch

y = Center Load, in hundreds of lbs.

Row No.	Class	Col. No. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	Av.X	f	dy'	fdy'	$f(dy')^2$
1	34	84 1																				25.000	1	−7	7	49
2	35							36 1				12 1										33.000	2	−6	12	72
3	36											10 1		2								36.300	3	−5	15	75
4	37								20 1	16 2	12 1				4 2	8 1						35.300	7	−4	28	112
5	38						21 1			12 1	9 2	6 1	3 5	1	3 1	6 1	9 1		15 1			36.100	15	−3	45	135
6	39				18 1	16 1	14 1		10 3	8 1	6 2	4 1	2 3	5		4 2	6 3					35.200	23	−2	46	102
7	40							6 1		4 1	3 2		1 1	1	1 2	2 6	3 2	4 1	5 1			37.700	18	−1	18	18
8	41							1		1		3	4	5	1	3	2	1				36.900	21		−171	
9	42									4 1	3 1	2 2	1 4	5	1 5	2 7	3 6	4 3	5 2		7 1	38.400	37	+1	37	37
10	43											4 1		4	2 4	4 3	6 1	8 1	10 3		14 2	39.300	19	+2	38	76
11	44									12 1			3 1			6 4	9 1	12 2				38.600	9	+3	27	81
12	45							24 2					4 1	2		8 1		16 2	20 3			38.100	11	+4	44	176
13	46						35 1							1				20 1		30 1		37.800	4	+5	20	100
14	47													1								37.000	1	+6	6	36
15	48																21 2		35 1			40.700	3	+7	21	147
16	49																					—	0	+8	0	0
17	50														9 1							38.000	1	+9	9	81
18	Av.Y	3400	—	—	3900	3900	4100	4120	3850	3980	3910	3980	4040	4130	4160	4140	4180		4310	4600	4270				+202 −171	
19	f	1	0	0	1	1	3	5	4	8	8	10	19	27	16	28	18	11	11	1	3	Totals	175		+31	1297
20	dx'	−12	−11	−10	−9	−8	−7	−6	−5	−4	−3	−2	−1		+1	+2	+3	+4	+5	+6	+7					
21	fdx'	12	0	0	9	8	21	30	20	32	24	20	19		16	56	54	44	55	6	21	+252 −195	+57			
22	$f(dx')^2$	144	0	0	81	64	147	180	100	128	72	40	19		16	112	162	176	275	36	147	1899				

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ed deviations, d_x and d_y for use in equation (1). It will be noted that the signs of the deviation products are omitted in Table III, but that in two of the quadrants into which the table is divided by the heavy ruling, the deviation products have a plus sign, and in two, a minus.

The mean product, p, is found from the correlation table with the help of Table IV. The sum of the totals of col. 2 and 3, disregarding signs, is 132, and the 43 missing, which are needed to make up the total of 175 tests, are found in col. 13 and row 8 of Table III, the deviation products for these 43 tests being zero. Care should be taken not to count twice the 5 tests in col. 13, row 8. From col. 5 and 6 of Table IV we have 692 - 63 = 629, and dividing this by 175, the total number of tests, gives $p' = 3.59$.

In order to correct p' and get the true mean product, p, we must first find the real average values of X and Y. In Table III, if we multiply the values of col. 22 by those of col. 23, we obtain col. 24, and a second multiplication by col. 23 gives col. 25. Similarly, rows 21 and 22 are obtained from rows 19 and 20. From the totals of row 21, we have $+252 - 195 = +57$ and dividing by 175 gives $+0.325$ class intervals or $+325$ lbs. per sq. in., which is the error in the assumed average of 37,000 for the tensile strength. Therefore M_x the true average, is $37,000 + 325 = 37,325$. Similarly, from col. 24, $+202 - 171 = +31$ which, divided by 175, gives $+0.177$ class intervals or 17.7 lbs., so that the true mean center load is $4,100 + 17.7 = 4,117.7 = M_y$. M_x divided by $M_y = 9.05$, to compare with Nagle's value of S/P=8. Now, having the mean product, p' about an assumed origin of co-ordinates, we can get the corrected mean product, p, about the true origin at the intersection of M_x and M_y by moving the X axis a distance of $+0.177$ and the Y axis a distance of $+0.325$ class intervals. This gives $p = p' - (0.177 \times 0.325) = 3.59 - 0.06 = 3.53$.

TABLE IV

1	2	3	4	5	6
Deviation Product	Frequencies Plus	Minus	Total	Products col. 1 x col. 4 Plus	Minus
1	6	6	0	0	
2	14	8	+6	12	
3	13	5	+8	24	
4	8	8	0	0	
5	2	1	+1	5	
6	9	4	+5	30	
7	1	0	+1	7	
8	3	1	+2	16	
9	4	1	+3	27	
10	7	0	+7	70	
12	5	1	+4	48	
14	3	0	+3	42	
15	0	1	−1	0	15
16	5	0	+5	80	
18	1	0	+1	18	
20	5	0	+5	100	
21	3	0	+3	63	
24	0	2	−2	0	48
30	1	0	+1	30	
35	1	1	0	0	
36	1	0	+1	36	
84	1	0	+1	84	
Totals	+93	−39		+392	−63

If M_x had been exactly 37,000 so that $d_x' \; d_x$ we should have had

$$\sigma_y^2 = \frac{1899}{175} = 10.85$$

the figure 1,899 being the sum of row 22, Table III. But here again we must move our axis of Y through the distance of 0.325 class interval, and we have

$$\sigma_y^2 = \sqrt{10.85 - 10.325(^2}$$

class intervals or 3,280 lbs. per sq. in. Likewise we have from the sum of col. 25 Table III, 1,297 ′ 175=7.40

$$\sigma_y = \sqrt{7.40 - (0.177)^2} = 2.72$$

class intervals or 272 lbs. We are now at last ready to find the co-efficient of correlation from equation (1), and

$$r = \frac{P}{\sigma_x \sigma_y} = \frac{3.53}{3.28 \times 2.72} = 0.396$$

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The probable error of r is found by equation (2) to be 0.043 so that the ratio of r to the probable error is 9.2 which is greater than six, so that we have a clear case of correlation, as found for cupola iron in Table I.

(To be concluded)

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THE DEVELOPMENT OF IRRIGATION BY PUMPING

By FREDERICK W. PARK

Editor's Note. One most naturally associates irrigation with large desert areas and collossal dams and reservoirs in the Far West. Mr. Park here gives the very latest developments in a field that surprises one in its many applications and conditions.

NOT many years ago irrigation in the United States was considered necessary only in the arid West. Recent inquiry disclosed that some kind of a course in irrigation was being given in nearly every agricultural college in the humid states. In a few years irrigation has crossed the continent; but while the leaders in agricultural development, in all parts of the country now recognize the possibilities of artificial water, it is not generally realized that, with intensified cultural methods in localities near good markets, supplemental irrigation may be more profitable in areas of greatest rainfall than in the valleys of the far West.

It has been demonstrated that some crops can be profitably irrigated whenever less than one inch of rain falls in a ten-day period during the growing season. When this period is exceeded, the days following until that inch is received constitute a drouth. Frequent drouths occur in all localities but irrigation is intensive farming and it is therefore to the orchardist, small fruit grower, truck gardener and those who have learned how to grow such a productive forrage crop as alfalfa that it offers greatest possibilities in humid areas. Where crops of great value are grown in areas of large average rainfall a small quantity of artifical water supplied in the dry periods not only insures a full crop every year but, in seasons of protracted drouths, the supplemental irrigation may be the means of increasing the production several hundred percent, and thus pay the entire cost of a pumping installation in a single year.

In Western states many rivers and streams have considerable fall and, with gravity flow, large areas of the low land in the valleys are irrigated by !mpounding water and diverting it through canals and ditches In Central and Eastern states, only a small percentage of the land can be irrigated by gravity and irrigation development in these areas has been almost entirely by pumping.

The cost of power for irrigation pumping has been lessened by more efficient water turbines, the instal ation of hydroelectric plants and adapting internal combustion engines to burn lower grades of fuel oils. In the Great Plains more efficient deep wells are now produced by the introduction of rotary well drilling machines, capable of drilling wells of very large diameter, and by learning how to develop these wells so that there will be largest delivery of water with least drawdown. In the distribution of water the duty has been greatly increased by the use of underground piping and overhead spray systems. All these, however, are accessory to the pump and

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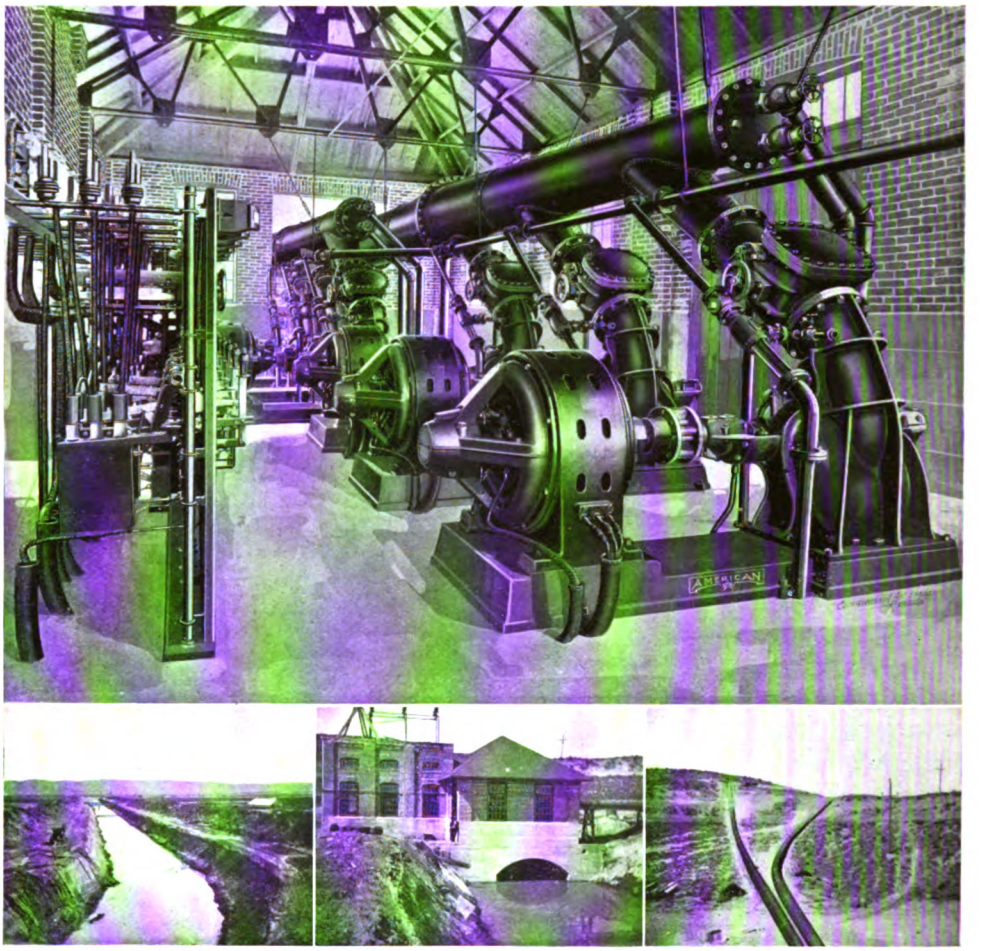

Fig. 1. Pumping plant of Snow-Moody Development Co., Payette, Idaho. At top, interior view showing six 14-inch "American" centrifugal pumps discharging into headers. Bottom, at left, canal extending from Snake River to pumping plant; in center, view of pumping plant showing forebay extending under pump floor; at right, two of the wood stave pipe lines leading from pumping plant.

it has been estimated that 95 per cent of all pumps installed for irrigation in the United States are centrifugals. The development of the centrifuga pump, therefore, may be regarded as the primary means which has made irrigation possible in all parts of the country.

In the development of irrigation by pumping the quantity of rainfall so regulates the conditions as to make the usual pumping plant entirely different ni arid, semi-arid and humid regions. In each of these areas a single style of plant predominates to an extent that it may be said to typify the installations of that region.

In the arid West, water for irrigation is usually obtained from rivers and streams which receive their supply from rain and melting snow in the mountains. The low valley lands are irrigated by gravity flow but there is a large, and rapidly increasing field for the pump in irrigating the higher bench lands. In this area the usual pumping plant is a large installation, the pumps, when

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possible, being direct connected to hydraulic turbines but more frequently direct connected to electric motors. Several thousand acres are usually irrigated by a single plant in this area.

A large part of the Great Plains has an annual rainfall of approximately 20 inches, most of which falls during the growing season. This appears almost enough water to produce a fair crop, but the high altitude, long periods of continuous sunshine, high velocity of the wind and the irregularity of the rainfall make it impossible to produce a full harvest, in most seasons, without supplemental irrigation. Some success has been attained by developing drouth resisting forage crops, notably the grain sorghams, but the soil is rich and deep and maximum yields are obtained only when crops receive a sufficient quantity of water. While there is deficient rainfall in this region, nature has provided a remarkable system for conserving water in the ground. In very extensive areas, no hard rock is encountered for several hundred feet below the surface. Beginning from a few feet, to as much as 75 feet, below the surface and extending downward from 100 to 250 feet are formations containing several beds of very fine sands through which the water percolates. There is usually a movement of the water in the general direction of the plain, but the sands are so fine and compact that the flow is only from a few inches to a few feet a day.

In early development, small capacity wells were sunk from which water was pumped into reservoirs for distribution on the land. Later, in Kansas and Colorado, it was common practice to drill several deep wells, spaced 25 to 50 feet apart in a line at right angle to the general direction of the underflow, insert in them steel casings having fine screens attached to the lower ends and pump them as a unit by installing a centrifugal pump in a deep pit and connecting its suction pipe with all the wells by tunneling through a few feet above the water table. Recent investigation has proved that these fine sands pack around a fine screen so tight that the flow of water is greatly retarded and there is a large drawdown when the well is delivering only a comparatively small quantity of water.

Present practice is to drill a single well as large as practical which, with the drilling machines now in use, is about 30 inches in diameter. The well is drilled from 150 to 300 feet deep and the lower 100 to 200 feet is in water bearing formations. In this well a steel casing is inserted, the lower end of which, extending entirely through the water bearing strata penetrated, is made into a coarse screen by punching 3-8 inch round holes spaced 1½ inches apart, center to center, throughout this length. The pump is then installed and operated at capacity for several days to develop the well, the object being to pump all possible sand from the water bearing strata in this operation. Several car loads of sand are usually pumped from a well during this development work. The result is that cavities, or small reservoirs, are formed surrounding the well casing in all the water bearing sand strata penetrated. This not only produces reservoir capacity, but affords many times greater area for the infiltration of water than a well having no subterranean reservoir development and in which water can only reach the well by percolating directly through the compacted sand around the casing. Several hundred wells have been developed by this method without a single failure and when completed deliver a minimum of about 1,200 gal-

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lons a minute, or a sufficient quantity of water to supply supplemental irrigation for 160 acres. It has also been proved that wells developed by this method deliver a large quantity of water with much less drawdown than wells fitted with fine screens and producing a relatively small flow.

Methods of well development in the Great Plains are given because in this area the efficiency of the well is as important in determining the economy of the installation as the efficiency of pump or engine. The usual type of pump, when greatest pumping depth is less than 40 feet, is a horizontal centrifugal installed in a deep pit with suction pipe extending down into the drilled portion of the well and operated by an oil engine at the surface, the belt connecting engine with pump leading down at about a 45 degree angle. When the pumping lift is greater than 40 feet a belt driven deep well turbine centrifugal pump is usually installed.

In Eastern states the quantity of rainfall provides an abundance of water for irrigation from rivers, streams or shallow wells and the problem is not so much of supply as of distribution. In this area, the topography and shallowness of soils frequently prevent leveling the land and conveying water in deep open ditches. The usual distribution is either by pumping water, under light pressure, through underground lines of watertight sewer pipe, laid along the high line of the land to be irrigated, and distributing it into ditches by means of hydrants and portable sheet iron pipe or by a spray system.

In the overhead, or spray system, water is pumped through piping extending over the fields and resting on risers about 7 feet above the ground. At intervals of about 3 feet along these lines are nozzles through which the water flows. As the water is forced through these nozzles it breaks into an exceedingly fine mist so that the impact on the ground is very light. Irrigation by this method does not have a tendency to bake the soil, does not injure delicate plants, provides an even distribution of water and is more economical of water than any other method. It is the most expensive system to install but it presents possibilities for intensive culture beyond any other kind of irrigation. Many of the greatest specialists in fruit, flower and vegetable growing, throughout the country, have their fields and green houses equipped with this system of irrigation.

As an illustration of the present progress in the development of irrigation by pumping, three installations have been selected, one each in arid, semi-arid and humid regions. These may be regarded representative of the most advanced practice in each of these areas.

An example of the progress of irrigation by pumping in the arid West is the installation of Snow-Moody Development Co., near Payette, Idaho. This plant is illustrated in Fig. 1 and, while it has been in operation several years, many features introduced in its design have been closely copied in other installations. The land irrigated is on the Oregon side of the Snake River and comprises about 6,000 acres. The slope is such that it is easiest watered as three benches, or lifts, each served by a seperate canal into which water is delivered by a wood stave pipe line.

For convenience the benches are referred to as A, B and C. The elevation of water in canal A above normal water level in the river is 108 feet, canal B 83 feet and canal C 48 feet. The quantity of water required for each 100 acres is 1 second foot. Canal A re-

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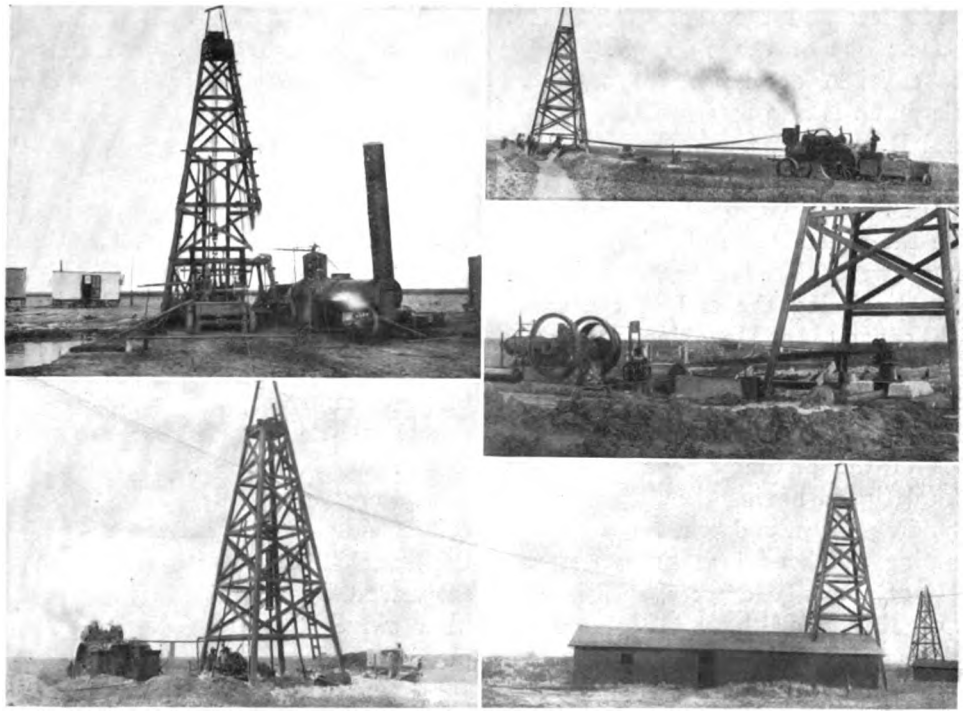

Fig. 2. Developing a large capacity irrigation well in the Texas Panhandle. Left at top, drilling the well; at bottom, installing the Deep Well Turbine centrifugal pump. Right at top, developing the well by pumping out the sand (about 50 carloads of sand were pumped from this well); in center, installing the permanent oil engine; at bottom, the installation housed complete.

quires 20 second feet, canal B 30 second feet and canal C 12 second feet.

The difference of elevation between high and low water in the Snake River at this point is about 8 feet. To reach the upper end of canal A from the Snake River would require about 3,600 feet of pipe line and nearly as large quantity for the other two canals. At the upper end of the land to be watered the low flat ground of the river bank extends in from the river over 3,000 feet. By digging a canal to this point and locating the pumping plant at the inner end of the canal only about 500 feet of pipe line was required to reach each canal. The cost of this open canal was less than to construct long pipe lines and friction losses in pumping through the shorter pipe lines was correspondingly lessened. The plant was therefore constructed in this manner, the level of water in the canal being controlled by head gates at the river end.

In this installation the land owners required that there should be two pump units for canal A each delivering half the required quantity of water, for canal B three units each having a capacity of one-third the total quantity of water and that a relay, or spare unit, be provided of not less than 10 seconds feet capacity which could deliver water into either canal. For canal C there are two units each having a capacity of one-half the total amount. These requirements are met by building six pumps of the same general design and capacity for canals A and B. The pumps for canal A are designed for a total head

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of 110 feet and those of canal B for 85 feet; one of the pumps delivering into canal A acting as a spare unit. This pump is also made to deliver into canal B by cutting a by-pass to allow 10 second feet to flow from canal A to canal B.

In the construction of this plant the pumps were placed directly over the sump by lining the end of the canal with concrete and making the walls heavy enough to carry the building. To economize floor space and provide shortest suction pipe and easiest flow lines in the discharge, special pumps were designed having the suction pipes extending directly downward and discharging overhead into headers at an angle of about 35 degrees. All pumps for canals A and B have 14 inch suction and discharge pipes and those for canal C, 12 inch suction and discharge. The 14 inch pumps were built by The American Well Works, Aurora, Ill., and the 12 inch pumps by Byron Jackson Iron Works, San Francisco, Cal. All pumps are direct connected to electric motors, power being received from a transmission line and stepped down by transformers in the pumping station. By designing special pumps for this installation very high efficiencies were obtained, the six 14 inch pumps have a mechanical efficiency of 84 per cent and the overall efficiency of the entire plant is 74½ per cent.

As typical of the progress of irrigation by pumping in the Great Plains, a well such as is constructed by several large operators in the Texas Panhandle is selected. Usual conditions and the most advanced methods of drilling and developing the well are given rather than a description of any particular installation. Views of the development of a well in this area are shown in Fig. 2.

In a region of small rainfall everything in irrigation depends upon a well that will supply the required quantity of water and the development of a well of largest capacity with least drawdown is therefore an important part of the installation. In nearly all of the present irrigation pumping areas in the Great Plains no hard rock is encountered in drilling a well. This condition is especially favorable for sinking large wells with rotary drilling machines using only what are known as earth tools. The rotary machines consist primarily of a derrick from the crown sheave of which are carried the drilling tools, consisting of a cutting bit with water orifices in its shank attached to the lower end of a hollow drill pipe and suspended by cable at top by means of a swiveled coupling which is also provided with a hose connection for the pump, a machine for gripping and rotating the pipe mounted on the derrick floor, the hoisting drum from which the drilling tools are suspended by cable leading over the crown sheave, a powerful pump for supplying the circulating water, and the necessary power which is usually a steam boiler and engine. With this process the drilling is done by the rotation of the bit and the water forced down the drill pipe and out through the water orifices in the shank of the bit carries the cuttings to the surface with the return flow of water on the outside of the drill-pipe. The discharge from the well is led by a circuitous trench to a pool, into which the suction pipe of the pump is inserted. This permits the cuttings to settle in the trench from which they may be shoveled and delivers comparatively clear water to the pool for the pump supply.

The derrick is usually 16 feet square at base, tapering to four feet square at top, the usual height being 42 feet.

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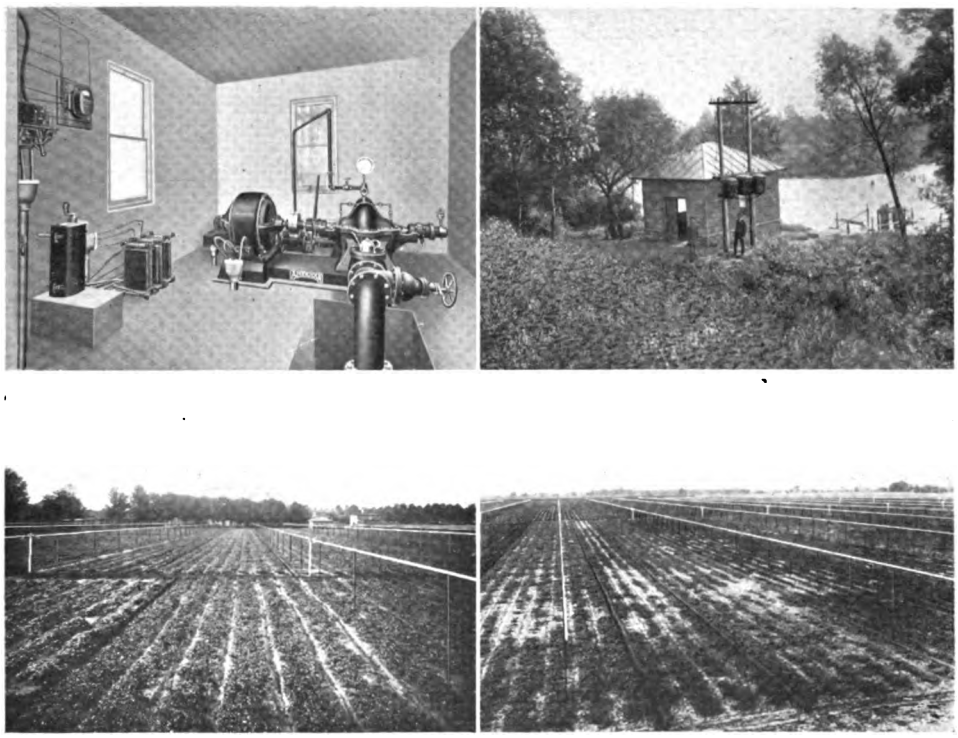

Fig 3. Overhead spray irrigation system of R. M. Kellogg Co., Three Rivers, Michigan. Top at left, interior of pump house showing 8-inch horozontal "American" centrifugal pump; at right, view of pump house and transformers. Bottom, two views showing a part of the overhead piping.

This derrick is strongly constructed and is left standing as a part of the permanent equipment for use in case repairs are required to well or pump. The well is located on the highest point of land to be irrigated. The drilling operation is begun by sinking a six inch temporary supply well with a churn drill, about 30 feet distant from the permanent well. In this temporary well a plunger pump having a steam working head, connected by steam pipe with boiler, is installed. This well delivers water to a tank for boiler supply and to pool for the pump when drilling the large well.

The permanent well is begun with an 8-inch fish tail bit and is rotated down the entire depth of the well, which we will assume is 200 feet. A 16-inch fish tail bit having immediately above it a five blade 30-inch reamer is then attached to the drill pipe and the well reamed out the entire depth to 30 inches in diameter Manned by an efficient crew the actual drilling time required in sinking and reaming the large well is 20 to 30 hours. Water is struck about 40 feet below the surface, below which are 6 to 8 fine sand water bearing strata in the total depth of this well.

When the drilling is completed the well is cased the entire depth with a No. 8 gauge steel casing. This casing is made into a coarse screen from the first water stratum to the bottom of the well, by drilling, or punching 3-8 inch round holes, spaced 1½ inches apart, center to center, throughout this length. A deep well turbine

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centrifugal pump is then installed and operated at capacity for several days, by any convenient power such as a large traction engine, to develop the well. This is the most important operation in the development of well as it is absolutely essential that several car loads of sand be pumped from the water bearing strata and thus form large reservoir capacity in all of the water bearing strata penetrated, in addition to greatly increasing the area in the sand formation for the free inflow of water into the well. The pump in this well is a 24 inch turbine with the bowl located at the lowest pumping level.

The allowance for draw down is 40 feet which will place the bowl of the pump 80 feet below the surface. Attached to the lower end of the pump is a 10-inch suction pipe extending to within five feet of the bottom of the well, or, in other words, the pump is equipped with a suction pipe 115 feet long. The long suction pipe is a necessary feature of this installation. Any part of a large capacity, coarse screened well in sand formations in which a current of water is not maintained will be rapidly filled with sand and that part of the well shut off. By pumping from the bottom of the well all of the water bearing strata are kept open and a permanent well of largest capacity is maintained. When this well is developed, a 70 horse power oil engine is installed as permanent power and housed as shown in Fig. 2. Many of these wells deliver as much as 2,500 gallons of water per minute, but 1,200 gallons per minute is considered ample to irrigate 160 acres.

The type of deep well irrigation installation described has obtained its highest development in the Texas Panhandle and in the Membres Valley in New Mexico. There are indications that many millions of acres in the Great Plains will be brought to a high state of production through this method of deep well supplemental irrigation within the next few years.

An instance of irrigation by pumping in the humid region is the overhead system of R. M. Kellogg Co. of Three Rivers, Mich., the largest grower of strawberry plants in the world. On this plantation 225 acres of strawberries are grown, 65 acres of which are under irrigation. Views of this installation are shown in Fig. 3.

This plant is located in an area of large average rainfall, but the irregularity of water was considered the greatest source of loss to the company. It was decided that the overhead irrigation system made by the Skinner Irrigation Co. of Troy, Ohio, was best adapted to their requirements and about a year ago the first unit of 65 acres was installed. To this additions will be made until the entire acreage is irrigated.

The lands of this company are low and level and the Portage River flows along one side of the farm and supplies an abundance of water for irrigation. The pump house was installed on the river bank from which a system of underground cast iron bell and spiggot pipe extends across the farm and is connected by risers with the overhead piping. All overhead piping is galvanized iron and ranges in size from 2 inch down to 3-4 inch, the greater the distance from the source of the supply the smaller the pipe. The overhead pipes are carried by hangars seven feet above the ground and at intervals of about three feet along these lines are bronze nozzles for distributing the water. The supply lines are placed 52 feet apart and the water when thrown horizontally overlaps the intervening space; the pipe lines being designed to spray

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a lateral distance of 28 feet. All pipe lines are provided with turning devices to permit them to spray to either side and they are also equipped with valves so that any part of the system can be turned on or off.

The pump supplying this system is an "American" 8-inch, single stage, double suction, horizontal centrifugal, direct connected to a 75 horse power electric motor and is designed normally to deliver 1,050 gallons of water per minute against a 176 ft. total head. A feature of this pump, however, is that while it has a mechanical efficiency of 73.5 per cent at its most economical delivery, it maintains an efficiency in excess of 70 per cent through a range of delivery of from 750 to 1,300 gallons per minute, especially adapting it to variable quantity service.

The operation of this system is divided into three shifts of approximately equal acreage. When in operation, about 60 gallons of water per minute are required for each acre, about four hours are required to saturate each 22 acre tract and about 12 hours to irrigate the entire 65 acres.

As further evidence of the possibilities of overhead irrigation it may be mentioned that means is now provided for automatically rotating the pipes; commercial fertilizers, insecticides and fungicides may be sprayed through the pipes and by spraying in low temperatures, plants may be protected from light frosts.

This is only an indication of the greater production from land tillage made possible by the development of the pump in irrigation.

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THE SWISS MILITARY SYSTEM

By JAMES A. TOBEY, M.I.T., '15

Major of the M. I. T. Cadet Regiment, '14-'15
Assistant in the Department of Military Science and Tactics

SHORTLY after the war of 1870 Bismarck conceived the idea that Switzerland should belong to Germany. The party of the second part was not agreeable, however, and immediately an army of one hundred thousand Swiss was mobilized on the frontier. Bismarck, who was a rather astute man, then decided that Germany could do without Switzerland, and the determined little nation is still independent. To be sure, her neutrality had been guaranteed in 1815 when Austria, Great Britain, Portugal, Prussia and Russia all signed a treaty to that effect. But it was not the piece of paper which influenced the iron chancellor; it was the best trained and most efficient army in all Europe. Earlier in the war the Swiss had met, disarmed and interned a French army of 83,000 men, which had retired toward their territory.

Today, bordered by four of the warring nations, Germany, Austria, France and Italy, in the very midst of the conflict, little Switzerland with an area about twice that of Massachusetts and a population somewhat less, is enjoying a calm peace, but ever alert that her national integrity be not violated. The reason that she has not been accorded treatment akin to that of Belgium is due to her wonderful system of preparedness.

The modern method dates from 1874 when the old system of the cantons furnishing three men out of every hundred for the army was abolished and universal compulsory service substituted in its place. The system is something of a marvellous paradox, for it is voluntary compulsion; voluntary in that the people, who have more voice in the management of their country than those in any other on earth, imposed it upon themselves of their own free will; compulsory in that they made it an article of the national constitution. The only persons who are exempt are clergymen, teachers, federal officials, police and employees of the hospital, prison, telegraph and postal services. All of these last are required to pay an increased tax, for the Swiss believe in equality and practise justice in the framing of their laws.

The army is divided into three classes according to the age of the soldier. These are: the "Elite," the "Landwehr," and the "Landsturm." The first is for men from twenty to thirty-two years old and is essentially the first line of the army. During their first year the recruits serve 65 days if in the infantry or engineers, 75 if in the artillery, and 90 in the cavalry. After that all except the cavalry are called out every other year, serving at these times for eleven days or so; the cavalry are discharged after ten years' service, but drill eight times during that period for eleven days each time. The landwehr is for men between the ages of thirty-two and forty, and is called out only once in that period for eleven days. The landsturm, which is a sort of reserve, has no duty except in case of war. It contains the men of forty to forty-eight years of age.

Although everyone is eligible for

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military service, not all are allowed to take it, for to become a soldier a rigid examination must be passed. It is the keenest disgrace which a Swiss can incur to fail in this examination and, furthermore, the defeated aspirant is compelled to pay a military tax ranging from 6 to 3,000 francs according to his income. The examination is physical and mental, the former part being very severe. The latter consists of reading, writing, arithmetic, history and geography. About one half of those who take the test are rejected. Those who pass are placed in that branch of the service for which they are best fitted.

The common soldier is not a high paid individual. In fact, he gets no money at all, but in Switzerland glory and honor are still considered of value. The soldier is given his uniform and full equipment, including rifle, which he keeps at his home, being responsible for their proper care and condition. The cavalry are furnished with a horse bought by the government, but for which the soldier pays one half. Every year for ten years, though, he is paid back one tenth of that sum and at the end of that time is also the owner of the horse. When not engaged in military duty he may use it for his own pleasure or work. While the soldier receives no pay, his uniform is as good as money to him. It is a railroad pass and all necessary goods which he may desire are furnished to him gratis by the people. Of course, he wears his uniform only when going up for drill. The Swiss realize that the enlisted man is a necessary adjunct to their peace and prosperity and they therefore respect the uniform. Contrast this with the attitude of some of our American states where a soldier in uniform may be ejected from a theatre if he rises in honor of the national anthem. "Those manners and ours, those morals and ours."

The training of the recruit is very thorough, and it is training and not drilling that he gets. It really begins at the age of ten, for, although his actual service does not commence until he is twenty, the foundation of his military career is laid in the schoolroom. Attendance at school up to the age of 15 is required by law. From the age of ten athletic and gymnastic exercises are the rule. No distinctive military operations are taken up, but the object is to produce young men with supple bodies and alert minds. Many of the boys in the public and private schools belong to organizations known as cadet corps, which are fostered and encouraged by the government. There are well over 50 of these corps, each having its own instructor from the regular army. At twenty the members of the elite mobilize in various training places, where they work and study eight hours a day, during their prescribed period. The work includes instruction in the school of the soldier, company and battalion, target practise, care of arms, cooking and hygiene. At the end of the term each man is graded according to the progress he has made.

Target practise is a national pastime in Switzerland, just as baseball is here. There is one basic difference, however, for there every one takes part, while here the majority look on. Rifle clubs flourish all over the country. Competition is keen and anything but an "expert" score would be treated with well merited contempt. Every commune has its official rifle range, every person has his own rifle to use on it. Soldiers have a prescribed amount of shooting to do, which they are permitted to perform on their own territory if they so desire.

The most credible thing about the Swiss soldiery is, perhaps, the spirit of democracy which everywhere prevails.

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Rich and poor are treated alike and want to be. There are no so-called 'crack regiments,' where the principle qualification is a man's social position; there are no expensive armories where dances are held every two weeks. Imagine a battalion of Swiss marching up Boylston Street; no gaudy uniforms, no gold lace, no prize winning appearance, nothing about them to the casual observer to cause admiration. But consider what they represent as fighters, then stand up and salute, oh you scoffer.

Promotion is by merit alone, and comes only from the ranks. There is but one general and he is the commander-in-chief. A rank of colonel is the highest in the army and to reach this grade a man must pass through all the preceding ones, which requires at least fifteen years. Political influence counts for nothing. In the Spanish-American war, the man who had the most friends at Washington got the biggest job and usually managed to wreak the most havoc--on America. Regimental and battalion commanders in the Swiss army are chosen by boards comprising the secretary of war, chief of the branch of service to which the candidate belongs, chief instructor and commander of his division. Although the soldiers form a militia and not a standing army, there is a permanent force of 230 officers who act as instructors.

The organization of the army at present is as follows: the elite is composed of six divisions, four cavalry brigades and fortress troops. They are completely equipped and have the best of transportation facilities. The landwehr is organized into 56 infantry battalions and 24 cavalry squadrons. While these last lack transportation facilities they can nevertheless be assembled anywhere ready to fight at once.

The thing which makes the whole system possible, however, is the spirit of the people. They are intensely patriotic and consider their country worth fighting for if necessity should arise. They are not aggressive, expansion is not their aim, but they are wise enough to perceive what would happen if they were not prepared for what surely would happen. In fact, the martial spirit so prevails that it must be occasionally restrained, rather than encouraged, though it is their boast that every child is born a soldier. The Swiss are altruistic—they regard the nation and not the individual; they endeavor to inculcate in the young that spirit of freedom and equality, of independence and self reliance which is essential to the welfare of any nation. They are all socialists there, militaristic socialists, practical men and not theorists; they act and do not talk. Here in the United States —but, as Kipling says, that is another story.

Whether the system is applicable to our own country is an open question. Everyone, even the professional pacifists, who decry any kind of militarism on general principles (and heaven only knows what are those principles) admit the value of the Swiss system. Incidentally, the framers of the Constitution of the United States made provisions for a similar citizen soldiery when they drew up that remarkable document. The standing army here numbers about 90,000 officers and men, while the various state militias aggregate about 130,000, of whom about one half would be of value in case of war, according to experts. Furthermore, we have no reserve at all. Some people think that an army fully equipped, trained and prepared could spring up over night in time of need.

When all is said and done it is a question as to whether there exists in the

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United States the spirit to foster such a system as that of Switzerland. This nation is the same that defeated England in 1776 and 1812, Mexico in 1847 (and again in ?), Spain in 1898. To be sure, we seem to be diverted somewhat by our ardent chase for the golden glory of the dollar. To be sure, a few insidious cowards sneer about the symbolic value of the stars and stripes, a few poltroons claim that soldiers are only the tool of the rich to grind down the poor and a few other jingoes wish us to blindly embroil ourselves in every real or imaginary conflict existent. But for all that, the heritage of old has come down to us,—we believe America worth fighting for and we will fight for her. There is the spirit, where is the system?

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WHY PREPARE?

By DONALD BELCHER, M. I. T., '15

Editor's Note. Mr. Belcher is known among many men at the Institute as a clear thinker, and one who will ably champion any cause in which he believes. While not necessarily espousing Mr. Belcher's views as an editorial policy, we believe he is making many Tech men think along lines that would not otherwise come within their reading.

A NATION of shop-keepers is sure to be a nation of phrase-makers. Shop-keepers, being so busily engrossed in vending oil, and sugar,and —munitions, must get their culture second hand. That is why so much of our American "kultur" finds its sole expression in phrases; you know the sickening lot: "hearth and home," what is home without a Mother?", "America first," "our country, be She right or wrong," etc., ad nauseam. We do not even create our own phrases, we let some ingenious Elbert Hubbard or Theodore Roosevelt, willing to prostitute a natural gift, make them for us. Technology students have had the word EFFICIENCY flung at them enough to know how utterly bankrupt most of our educators and public men are. Some of them may realize that the cult of "pep" and "hustle" is not likely to share the laurel wreaths of posterity with the philosophies of Kant or Tolstoi. To show how utterly candid and impartial I am, let me say that the celestial band of socialists with which I often sit in earnest speech is not above living by phrases. Witness the oft-repeated "economic determinism" of "industrial evolution," etc. But this is somewhat beside the point; the phrase I wish to dwell upon is

"IN TIMES OF PEACE,
PREPARE FOR WAR"

Truly, this is a good phrase as phrases go; a very good phrase if you will ever stop to think what it means. But our bustling citizens have no use for the meaning of a phrase, they only love its comforting sound. Like the barber who advertises "special attention paid to every customer" (read it over, gentlemen, take your time), they seldom know what their mouths utter. To that great army of preparedness advocates, the phrase means: if you build enough battleships, train enough men, store enough munitions, no nation will dare to attack you, and in all probability you will live in peace for the rest of your days. On this point I propose to dwell presently. Some of the less optimistic among those who would prepare, do not claim that we are so likely to avoid war, but that we will emerge successfully from any conflict. This latter and more rational theory I intend to treat later on.

"In times of peace prepare for war." Surely, if you want war, why not prepare for it? But if reason still resides among men, who can claim that preparing for war can possibly prevent it? Germany prepared as no other nation has ever yet prepared. Did that prevent Germany from having to fight half the world in the forty-fourth year of her national existence? Oh, you say, Germany provoked the war. Ask a German of any rank or station that question and hear the thundering (and if you omit the diplomatic or imperial voice) sincere, No! But, you say, *we* will never wage an aggressive war; *we*

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can never be deceived as to whether a war is offensive or defensive. An idle boast. At the Socialist Congress, at Stuttgart, in 1907, the very question was raised. The chief spokesman for the Germans, I think it was Bebel, assured the gathering that the German socialists would always be able to distinguish between wars or offence and defence. O where, my countrymen, was German socialism in August 1914?

No. Germany, whether her millions wanted peace or war, got—war. Did Russia, troubled by finances, labor troubles, and lack of railroads, hesitate to tell great Germany and well-armed Austria to keep hands off Serbia? Did little France, with falling birth rate and anti-militaristic propaganda, hesitate? Some misguided soul said at a recent meeting of the M. I. T. Forum that if Roosevelt had been president of the United States Germany would never have dared to sink the Lusitania. What innocence! Germany was prepared, yet Russia and France defied her. England was prepared upon the sea, yet Germany risked, and probably lost, all by violating the neutrality of Belgium, giving England a valid excuse for entering the war. Every nation in Europe was prepared beyond the possibility of unorganized America; nearly all of them are cutting each other's throats.

William G. Sumner, the Yale economist and sociologist, had no delusions upon the subject of preventing war by arming. In 1903 he wrote:

"If you prepare a big army and navy and are all ready for war, it will be easy to go to war; the military and naval men will have a lot of new machines and they will be eager to see what they can do with them. *There is no such thing nowadays as a state of readiness for war.* It is a chimera and the nations which pursue it are falling into an abyss of wasted energy and wealth. . . . A wiser rule would be to make up your mind soberly what you want, peace or war, and then to get ready for what you want; for what we prepare for is what we shall get." (Italics mine.)

Perhaps the underlying cause of the present war is not clearly understood by all the readers of the Technology Monthly. It was, of course, trade rivalry in the East. And what caused the trade rivalry? Not only socialists know that Capital, particularly in Germany and England, had exhausted the local fields where tremendous returns could be had. It was to the Orient that Capital had to turn, to get fifty, or one hundred, or two hundred per cent. Hence the war. Do you want to arm and drill and tramp and pay taxes for such a sordid cause? If we ever have a war, it will be because we deliberately provoke it, or because we insist on fighting for our national "honor," or the Monroe Doctrine, or some other phantasmagoria. Before we lay too great an emphasis upon our national "rights," or our commercial desires, we had better clean up such affairs as the hideous murder of Frank in Georgia, or the Colorado situation. Before we utter too many phrases about the Lusitania or the Ancona, we had better see to it that the Eastland disaster can never recur. We cannot pretend that all the frightfulness belongs to Germany. If we have not yet employed poisonous gases, we *have* choked children in Southern cotton mills. If we have not yet butchered Belgians, we *have* a Colorado, a Paterson and a Lawrence. We have no Miss Cavell, but we *have* a Leo Frank and a Hillstrom. If we have not a wartime censor, we *have* an Anthony Comstock and a Curley.

No. You cannot convince me that I should regard humanity as divided geo-

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graphically. The people who love the things I lov eand who hope for the things I hope, are called Germans, Russians, Frenchmen, Italians, or what you will. I shall not arm to kill or maim Fritz, Ivan, Pierre or Giovanni, because some one has deluded him into thinking I am his foe.

CAN WE PREPARE ?

Of course, the ridiculous thing about preparation is that it cannot really be done effectively. You would scarcely expect anyone but a military man to be mistaken about that. The naval race between England and Germany presents an interesting example of the futility of trying to get ahead or even keeping up with the other fellow. We add a battleship, Germany adds two. We add two more and Germany one more and catches up; and so ad infinitum. To say nothing of the remarkable rate at which these war implements become scrap. Lord Roseberry said a few weeks ago:

"I know of nothing more discouraging than the announcement that the United States is about to build a huge armada. It means that the burden will continue upon other nations and will be increased exactly in proportion to the fleet of the United States." The result of our arming against Germany who seems to be selected as our future foe (Heaven knows why) can only be for Germany to scent trouble and prepare for another "*Tag*." This will be very pleasant for the Krupps and the Maxims who will become richer than Croesus, but what a day for you and I!

I had thought of entering upon the interesting and fruitful subject of non-resistance, but it would lead too far afield for this article. Perhaps, if this article calls forth any of the vexed spirit that my courageous soul tells me dwells in the Institute, the Monthly will later afford me a few more paragraphs. In the hope of arousing some opposition on the part of my readers, I must remark a fact too little known to a Christian nation: namely, that Christ preached absolute non-resistance. The Bible affords the only reliable evidence upon this question, but I do not wish to put shame upon any of my readers (who like to call well-meaning socialists atheists) by inviting them to a careful perusal of the New Testament.

In conclusion, let me say that when I first thought of submitting such an article as this to the Monthly, I was quite exercised over the movement for preparedness. A certain calm has fallen upon my spirit of late. Congress, after the fashion of Congress, has already begun to make a political wrangle of the issue. The middle states seem to regard the matter with no great favor, and societies of some influence are strongly opposed to preparedness. What passes for our democracy and industrial efficiency, so necessary to preparedness, do not go hand in hand, my friends. Fear not. Preparedness costs too much; we are too busy making money. But I hope what has been done may never go any further. I hope we may be the race that Shaw makes Caesar foresee:

"If one man in all the world can be found, now or forever, to know that you did wrong, that man will have either to conquer the world as I have, or be crucified by it. Do you hear? These knockers at your gate are also believers in vengeance and in stabbing. You have slain their leader; it is right that they shall slay you. If you doubt it, ask your four counsellors here. And then in the name of that *right* shall I not slay them for murdering their Queen, and be slain in my turn by their countrymen as the invader for their fatherland? Can Rome

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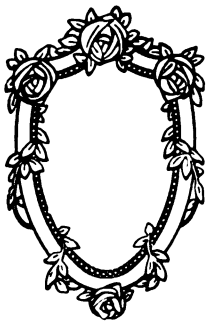
do less then than slay these slayers too, to show the world how Rome avenges her sons and her honor? And so, to the end of history, murder shall breed murder, always in the name of right and honor and space, until the gods are tired of blood and create a race that can understand."



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THE WRESTLING SEASON OF 1916

By G. H. STEBBINS, M. I. T., '17
Manager of Wrestling

THIS year the wrestling team has made several changes in its policy of previous seasons. In the first place, the team, this season, will confine itself entirely to college meets; having in all six to eight of them. In other years it has been the custom to have the bulk of the wrestling schedule composed of Y. M. C. A. meets with never more than three college matches. This was due primarily to the fact that the latter meets were easy to obtain while we had neither reputation or money to induce college teams to wrestle with us. The championship team of 1913-14, however, gave us the reputation and other circumstances have made our financial standing better, so that this year's schedule will include at least six meets with desirable college teams.

For the first time in its history, the wrestling team has secured for the winter the services of a paid coach, Mr. Levi Lamb. Mr. Lamb last year graduated from Penn State College where he wrestled for three years on the varsity wrestling team and captained it in his senior year. Being a heavy weight, Mr. Lamb is well able to give conclusive demonstrations of the points which he desires to bring home and is also of suitable weight to develop those classes of our team which are by far the weakest. This step of hiring a coach was made possible by the Blanket Tax which was instigated this year. The wrestling team always has been absolutely self-supporting, but the return from this tax enabled the athletic association to help us materially this year.

The wrestling season of 1916 will open with a trip to Pennsylvania during the mid-year vacation. On Monday of that week we meet Penn State at State College, Pennsylvania. The following Saturday we wrestle Lehigh University at South Bethlehem, and there is a possibility of visiting Lafayette in the middle of the week.

This trip is, without a doubt, the toughest proposition which our team has yet undertaken. Penn State has, for years, been at the top rank of college wrestling. There wrestling rates in popularity second only to football. The whole school turns out to see the elimination bouts for picking the first team, while at a regular meet, the gymnasium is crowded to the rafters. The Penn State team is, for the most part, composed of star men who have wrestled for a couple of seasons without the loss of a bout. Lehigh also turns out stronger teams than the colleges in this part of the country and much that has been said about Penn State applies to Lehigh as well. Against such an organization as this, our team—until this year self-coached—cannot hope to compete on anything like even terms but it can put up a strong fight and to this end the wrestling team is at present directing its entire energy.

Beginning the second term of the school the wrestling team will have a meet every Saturday thru March 11th. We wrestle Springfield Y. M. C. A. college the week after vacation, probably in our own gymnasium. Springfield last year barely secured a victory over us

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and the meet this year should be close and spirited. Another old rival visits us the following Saturday in the shape of Harvard. Last winter, they beat us and this year both teams will fight harder than ever.

On February 26 we go to Providence to meet Brown and should win this match as we did last year. For March 4th we have a meet scheduled with Yale but as yet the matter has not been definitely closed. Our team has met Yale but once—two years ago when we won from her the championship. This year it will be much harder to beat her for she has now the strongest team in New England.

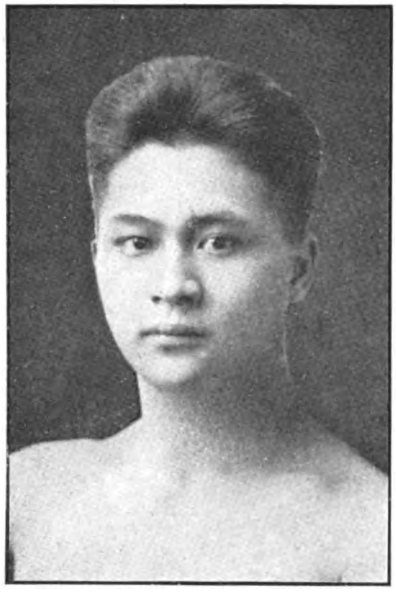
The biggest event of the present season will be on March 11 when an open meet for all New England colleges will be held. This will include Yale, Harvard, Brown, Springfield, Technology and possibly others. This meet will decide the New England Intercollegiate Championship at each weight. That is, the men enter as individuals and not as a team. We have several wrestlers who should show up well in this meet, particularly Captain Loo and Giles.

The complete schedule for the season is as follows:

Jan. 31—Penn State.
Feb. 3—Lafayette (indefinite).
Feb. 5—Lehigh.
Feb. 12—Springfield Y. M. C. A. College.
Feb. 19—Harvard (home).
Feb. 26—Brown.
March 4—Yale (indefinite).
March 11—Open meet.

All meets except those indicated will be away from home.

Eight members of last year's team, including substitutes, are wrestling again this year. These men are Loo, Bone, Rounds, Stebbins, Giles, Hoffman, Morse and Bond. We lost several good men by graduation last year while several more are too pressed in their work to find time for wrestling practice.



PING YOK LOO
Captain of the Wrestling Team

In the 115 lb. class Captain Loo is still the old standby although Bone and Means are each coming along rapidly. Rounds and Stebbins are both on the job again at 125 lbs., but both find the same old difficulty in getting down to weight. For new material McFarland and Wooten are both showing up strong.

Two reliable men, Giles and Hoffman, are still available in the 135 lb. class. Each won his letter last year and each intends to duplicate the performance this season. Morse is back in the 145 lb. class after a year's absence from the game and his presence strengthens the class materially. A freshman, Elwell, is also making a remarkable showing in the same class. In the 158 lb. class we have Bond, Wirt and Hunt. Bond

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wrestled twice last year on the team but outside of this, all of these men lack experience.

In the heavier classes material is woefully scarce. Todd, Root and Sullivan, all absolutely green men, are the only ones available in the 175 lb. class, while Sache, a freshman, who has had a little previous wrestling, will probably fill the heavy-weight class. These "heavies" have all been turned over to Lamb and it is hoped that, in spite of the scarcity of men, he can get some material into shape.

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THE MAN IN THE STREET*

A Tale of the New Technology

JAMES EDGAR THORNE was a quiet, unassuming sort of fellow—at first. When he came to Tech, he had sincere and laudatory intentions of doing nothing but studying. But then his home was out where the west begins, and that is a long way from Boston, which may or may not account for the fact that his good intentions faded slightly. Of course, he wrote daily letters home to his mother, at least for a while. After that they gradually dwindled to one a week or so. It was not that his regard for her had diminished in the least—not at all. She was all he had to care for. His father—well, the less said about him the better. But track and class activities and that sort of stuff took up a good deal of his time and he couldn't be tied to a woman's apron strings, even if she were the bravest, kindest little woman in the world. Not he.

Yet, often when he sat alone in his meagre room, late at night, after the math had left his brain awhirl and the chem had reduced him almost to an irresponsib'e idiot, he would toss the books away, tilt back his chair, rearrange his thoughts, and with his hands clasped behind his head recall that day when he left home for the first time. You know, his mother had been very proud of the honors he won in the local high school and she expected so much of him at Tech. When he had graduated and become a noted electrical engineer, then he would return the money his crabbed old uncle had so begrudgingly lent him to pay his way through. He would build a new house for the folks at home and pay some good doctor to cure his father of his taste for drink. He remembered how his dad could never keep a job, though he was an expert in his line. He was all right when he was sober and a good companion, but a brute when he was drunk. He had been so highly respected once, too. But now—well he would change all that when he was getting big money as a consulting engineer. Yes, Jimmie Thorne was a dreamer

But things hadn't been going any too well. The studies were so hard and the instructors so unsympathetic. Then he had been disappointed when he had to refuse the bids of a couple of fraternities who wanted him so badly. They were nice fellows, the Alpha crowd, but the Omegas were even better. Yes, if he had only been able he should have joined the Omegas. They wanted him, sincerely and earnestly wanted him, that he knew, because Jack Smith and Buck Jones had come over to his room and pleaded with him to join. They tried to take him to a show, but he had to study descrip that night and had regretfully declined. That was when he first came to Tech, though.

It certainly was tough to be poor; he couldn't even subscribe for the "Monthly" and he wanted to so much. But he made the freshman track team all right; he shone there. They didn't cheer the richer fellows any more than they did him when he beat Buck Jones in the relay and incidently won Field Day for his class. Even Jones slapped him on the back and said, "Darn good, old man." He liked Jones, he liked all

*A year's subscription will be given to the first person guessing the author of this article. Replies should be addressed to the Contest Editor.

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the fellows Jones went around with. They had money, though, and Jones had his own machine. So, although they wanted him to go to shows and little suppers, as they called them, he simply couldn't afford it.

Thus one night Jimmie sat alone in his dormitory and looked out at the river, watched it as it sparkled and glittered from the lights along the esplanade. It was Mid-year Vacation and most of the fellows had gone home or had been invited to some other fellow's house for the holidays. The dorm was very quiet and Jimmie was very lonely. Down at the fraternity house at the corner of the ell of the building there were lights and noises, for some of the boys who lived too far away to go home, as he did, were having a little party.

Not being able to endure the solitude any longer, he got up, went down and sauntered casually in the direction of the fraternity. They were singing inside. It was very comfortable and warm there, a sort of luxurious warmth. The curtains were up and Jimmie quite unintentionally, quite accidentally, so to speak, happened to wander rather close to one of them. They had a big log fire in the fireplace and a big keg on the table near the lounges in the corner. Kegs didn't shock Jimmie any more. They had at first, but he had even taken a stein of beer himself at the last Kommers Dinner. Beer is all right, you know, that won't hurt a fellow any; it's the stronger stuff that's bad. Anyway, Buck Jones drinks lots of beer and everybody thinks highly of him.

It was late when Jimmie started back to his room. The fellows were still around the piano when he left; of course they didn't know he had been there, they never think of the man outside, the man in the street. As he was about to enter the dark hall he heard a call. A crowd of a dozen or so fellows were coming boisterously across the campus. One of them was his admired friend, Buck Jones.

"Come on down town, Jimmie," he sang out, "we are going to have a little feed. This is on me. Just got a check from the governor. Mid-year present, you know." Jimmie stopped short in the doorway. Buck came up the steps and took him by the arm. "Come on," he said. And Jimmie went.

They all linked arms and marched across Harvard bridge singing that symbolic song, "There's a Tavern in the Town". Thence down to the Massachusetts station of the subway, where they obstreperously boarded a car. They almost had to argue forcibly one time with the conductor, for Dick Craighead was unusually noisy and persisted in offering his seat to each lady there. Two of the boys calmed him down, however, and they reached Scollay Square safely.

The Blue Boar was ready to welcome them and the head waiter, whom most of them called by his first name, showed them to a table. He looked a little curiously at Jimmie, for this latter had not been there before. It was not the most fashionable restaurant in town, in fact, was patronized more by the Bohemians—people who were looking for a good time. The supper was exceptionally good; there was an abundance of things to eat and drink. Dick Craighead fell asleep when he was only half through. Everything was jolly, though. It did Jimmie's heart good to be with such a jovial crowd. After they had sung their one hundred and third song, Buck, who was acting as master of ceremonies, called out, "Say, fellows, I've got an idea. Let's get some man

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from the street and tank him up as a present."

This suggestion was hilariously hailed with approval. Bob Bursted and Ralph Enger immediately and somewhat unsteadily rushed to the door. They soon reappeard with a miserable specimen of humanity in tow. He was disheveled and already somewhat inebriated.

"Boysh," he prattled, "you young fellers are all right-hic, all right. But you can't make fools of me."

Loud jests and much laughter greeted this sally and various jokes were levelled at the derelict.

"Sing us a song, old top," said Jack Smith, "Jimmie, you sing a duet with him."

But Jimmie, who up to this time had been the life of the party, had become silent. He had put down his pewter mug and was looking straight ahead, but not at any one in the room. Smith was too befuddled to notice this.

"Boysh," continued the drunk, "I wasn't always a bum-hic. I had a wife once." He leered around at the crowd.

"Go on, old soak," cried Smith in great delight, "Say, boys, he's going to tell us his life history."

"Just fill up that glass again, will you boysh. Thanks. Ah, that's good-hic. It's got me, though-hic. You young fellers better leave it alone, it'll get you, too-hic. Yes my wife was a good woman-hic-a goo' woman. I'm sorry that I treated her the way I did. I donno-hic where she is now; I guess she's dead. Thanks. I wasn't always a bum-m-m-m---" His voice died away. He was very much intoxicated.

"Revive him for us, will you, Jimmie," sang out Jack Smith.

But Jimmie had risen and was standing straight and there was a determined look on his face. The old home had flashed before his eyes; he remembered a night a few days before he had left for school. His father had come home a little worse than usual and had threatened to strike his mother and Jimmie had knocked him down. When he had left a few days later, his father had gripped him by the hand—he remembered how it shook—and promised never to touch the poison again. But—

"Why where are you going, Jimmie?" inquired Buck Jones.

"Home," answered Jimmie.

"To the dorm?" asked Jones.

"No," said Jimmie, "Home."

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General Offices of the Publication, 42 Trinity Place, Boston, Mass.

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All manuscripts submitted for publication in the TECHNOLOGY MONTHLY AND HARVARD ENGINEERING JOURNAL should be accompanied by the writer's full name and address. Manuscripts not accepted for publication will be returned only if the author so requests. Photographs, drawings, etc., will be returned to the contributor immediately after publication.

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EDITORIAL

HARVARD AND HER SCHOOLS

THERE has long been existent among many Tech men a custom of referring to Harvard in a most sarcastic manner, and relegating it to the ranks of a kindergarten. This is mostly due to the noticeable lack, among the men who spend their entire college life here at Tech, of the results of a liberal education and their consequent inappreciation of purposes. Harvard College offers a liberal education in its undergraduate courses and it stands very high in this respect. It is not in any way intended to be an engineering school. A liberal arts college requires of its students much outside reading and thought. Since many Tech men erroneously regard this with more or less contempt a false impression of Harvard College has arisen.

This impression includes all that goes by the name of Harvard, and her engineering school has consequently suffered. Conceit is rather common among Tech men; and most all are proud of the 'Stute's reputation for hard work. It is rather natural, then, that this feeling should arise, since we do not know how to differentiate (not here used in the mathematical sense).

The Graduate School of Applied Science of Harvard University is of recent foundation as compared with Harvard College. During this time, however, a school has been founded which stands unusually high in engineering, and which is on an equality with Tech in the thoroughness of its work. Harvard's other Graduate Schools, such as Law and Medicine, stand as high as any in the country.

The benefits that Technology will get from its alliance with the Harvard Graduate School of Applied Science, which was entirely due to President Maclaurin, will never be fully appreciated until the average Tech man really understands what is meant by "Harvard" and "Harvard's Graduate Schools."

EFFICIENCY FOR ENGINEERS

TOO often the requirements of higher education lead to a neglect of bodily training and health. The scholastic demands at Technology are such that a large percentage of the student body take insufficient exercise, sleep too little and deny themselves the proper amount of beneficial recreation. There is nothing particularly startling about this statement, yet every man in Technology should be brought to realize that bodily vigor is conducive—indeed almost essential—to mental efficiency.

It is astonishing how many well educated people are ignorant of even the fundamentals of hygiene. Their acquaintance with fresh air is a passing one, they have never heard of Fletcherism; they are sparing of water inwardly and outwardly; they care for their bodies only when the doctor requires it.

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In these days of "preparedness" it would be well for each of us to fortify his physical condition. Technology has her athletic teams; they afford ample opportunity for beneficial exercise. Although our Institute gymnasium is inadequate there are others in Boston which are open to Tech students. And finally there is probably no more healthy nor invigorating exercise than brisk walking in the fresh air.

Certainly one can not be censured if he be born with a weak or sickly constitution; however, with every opportunity for physical development, he can scarcely be excused for remaining so. The man who neglects his body lessens measurably the keenness of his brain and diminishes his power to enjoy the best in life.

PRACTICAL ILLUSTRATIONS IN TEACHING

One of the greatest aids in understanding a subject, from the student's viewpoint, is showing how actual use is made of the subject. Without it the problem is entirely abstract.

To some students abstract propositions of any nature whatever are highly acceptable. But the number of students so endowed by nature is small. The great majority of us need to see how a thing actually works. We can then understand it more readily.

Also, it is more efficient. It is entirely reasonable that if we see how a thing actually works we can do more than if we must think of both **how and why** it works just so. It is much easier to understand the theory of electrolytic dissociation if we can see precipitates form or color changes in solutions than if we had to imagine the entire thing.

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HARVARD GRADUATE NOTES

'03—John Howe Hall was married on November 10th to Miss Gertrude Earnshaw at Orange, N. J. Their address is High Bridge, N. J.

'09—George F. Williams was married in Waltham, Mass., on August 10th to Miss Eva Ellis. Their residence is in Balboa, Canal Zone, where Williams is a mechanical engineer with the Isthmian Canal Commission.

'10—Charles A.Wright, formerly with the American Telephone & Telegraph Co. in New York City, has accepted a position as Associate Professor of Electrical Engineering at Iowa State College, Ames, Ia. His home address is 517 Ash Ave., Ames, Ia.

'10—S. Stanley Kent, M. C. E. '11, is with the Massachusetts Board of Harbor and Land Commissioners, State House, Boston. His residence is 40 Kirkland St., Cambridge, Mass.

'15—P. S. Donnell has returned from Alaska, where he was employed through the summer by the U. S. Coast and Geodetic Survey in the region of Totem Bay. He has recently accepted a position with the Western Electric Company, New York City.

'15—W. C. Atwater is employed as State Bridge Inspector of a concrete bridge being constructed over the Platte River at Overton, Neb.

'15—A. P. Gradolph is employed in Mystic, Conn. with the firm of C. Hillsmith & Co., as engineer in the work of establishing the Climax Company of Lowell in its new location.

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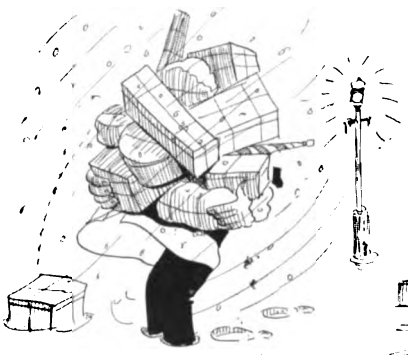
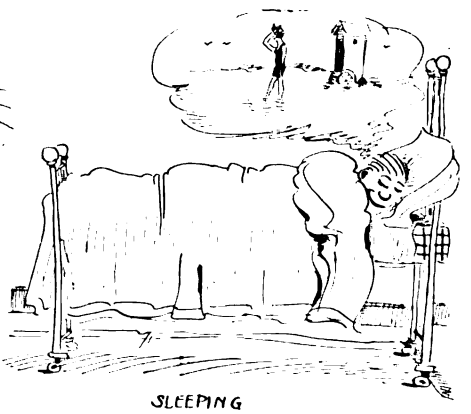
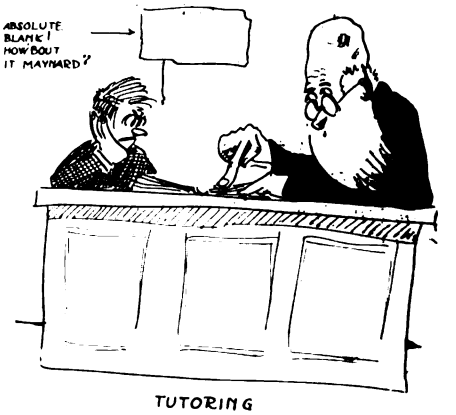


CHRISTMAS SHOPPING



SLEEPING

GUESS THIS!



TUTORING

AFTERNOON TEA DANCING

SKATING ?

HOW SOME OF US SPENT OUR XMAS HOLIDAYS

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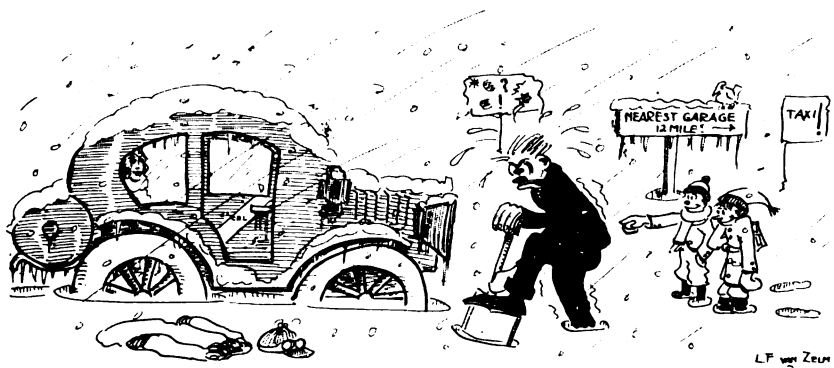
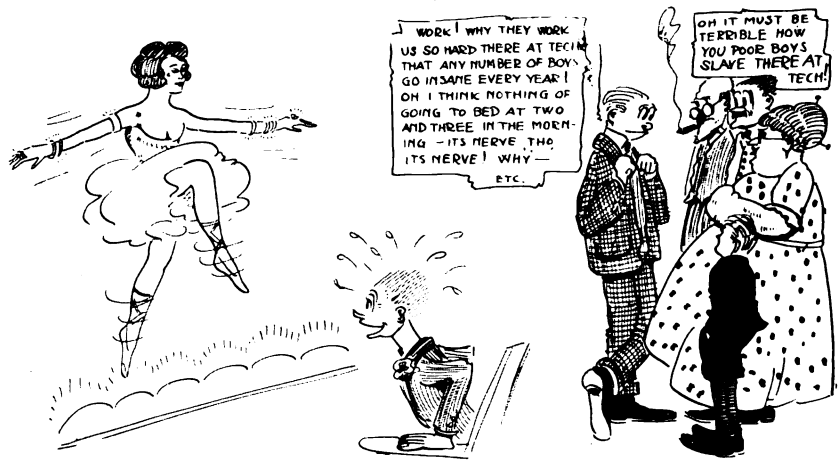
WHEN THEY HIT NEW YORK

GETTING RID OF THE GRIPPE



— MOTORING —

L.F. van Zelm
1918



ATTENDING THE THEATRE

BULLIN' ABOUT HOW HARD YOU WORK

HOW SOME OF US SPENT OUR XMAS HOLIDAYS

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OH THAT PRETTY BROWN SLUSH - OH SLUSH!

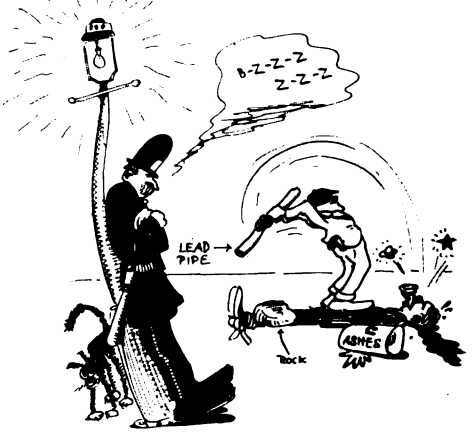
SOME FOLKS ARE WISE - THEY TIE THEIR FLIVVERS WHEN THE WINTER WINDS DO BLOW.

"WHEN WIFIE TAKES A TUMBLE ON THE ICE IN COPLEY SQUARE"

SUNG TO THE TUNE OF - "GOD RAISE THE QUEEN"

THAT MEAN WIND ON THE CORNERS

YOU DON'T REMEMBER THIS YOURSELF DO YOU? WHY? BECAUSE --



"ANY OLD NIGHT — ETC

RECENT SCENES AROUND COPLEY SQUARE

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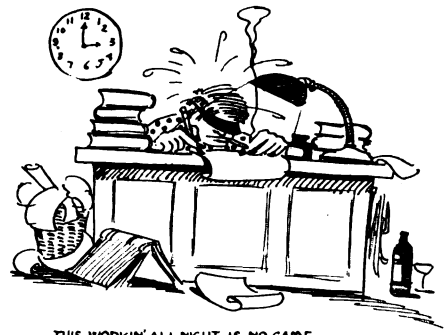
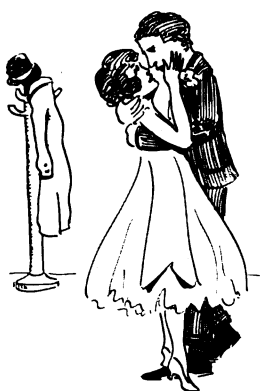
ITS FUNNY HOW A LITTLE BEER
WILL MAKE ONE FEEL SO DOG GONE QUEER.
A COUPL' A BRONX, SOME GIN AN' SHERRY
AN' ONE'S NOT TIGHT,—JUST HIGH AN' MERRY,
BUT NEW YEAR'S HERE AN' SO I CHOOSE
TO CUT OUT ALL THIS —— —— BOOSE.



THIS WORKIN' ALL NIGHT IS NO GAME,
ITS ENOUGH TO DRIVE ONE RIGHT INSANE,
AN' THERE'S MANY A WRECK IN BOSTON TECH
HAS THE BRAINS TO SWEAR OFF THE SAME.



ITS ALWAYS BEST IN EVERY SEASON
TO SWEAR OFF THIS – 'CAUSE THERE'S A REASON

SHE SAYS I HASSAN ANY WILL
AN' CANT CUBE CUT MY SMOKIN'.
I'LL MECCA SEE I HAS WILL STILL.
AM' ITS BULL THAT SHE'S BEEN POKIN

L.F. van Zelm
1918

TO SLEEP IN LECTURES IS GREAT DOPE,
WHEN ONE IS TIRED AN' BLUE
BUT BLAME IT ALL ITS DAMYN POOR DOPE
WHEN MARK'S COME HOME TO YOU
SO I'LL TURN OVER A BRAN' NEW LEAF
AN' LEAF THE SLEEP ALONE

OH I WON'T BE INQUISITIVE!
IT REALLY ISN'T RIGHT,
BUT HOW MANY MEN MADE THIS RESOLVE
'FORE THEY WENT OUT'N' GOT TIGHT?
OH THERE WAS LOTS T'WAS SAID AN' DONE
ON TH'EVE OF NEW YEAR'S NIGHT

PERFECT METRE HERE, BUT DON'T YOU CARE — STRETCH A THOUGHT!

P.S – DEAR CO'EDS, I APOLOGIZE FOR THIS PICTURE – I FORGOT IT WAS LEAP YEAR

A FEW NEW YEAR RESOLUTIONS BY OUR TECH MEN --- WHICH ONE WAS YOURS, OR DID YOU MAKE THEM ALL?

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LOCAL COLOR

MA'S APPREHENSION

Mother to father after hearing her son rehearse the Greek alphabet—"Ezra, we can't let Silas go back to college again."

"Why not?"

"He has learned to swear. I just heard him say Alfred beat-her, damn-her, pelt-her."—Penn State Froth.

One evening during the summer as Pauline's mother was putting her to bed, she said:

"Now, go right to sleep, dear. Don't be afraid, for God's angels are flying around the room and watching over you."

Shortly after, while the mother and father were reading in the library, the child called to her mother.

"Yes, dear," replied the mother, "what is it."

"God's angels are buzzing around just awful, mother," cried the little girl, "and one of 'em's bitten me!"—Chicago Herald.

A FEARFUL OCCURRENCE

A gentleman farmer tells of a city lad who once worked for him.

The lad was called one winter morning before dawn and told to harness the mule to the dearborn.

The lad was too lazy to light a lantern, and in the dark he didn't notice that one of the cows was in the stable with the mule. The farmer, impatient at the long delay, shouted from the house:

"Billy! Billy! What are you doing."

"I can't get the collar over the mule's head." yelled back the boy, "His ears are frozen."—Collier's Weekly.

Little Fellow: "If I fall and break my neck, I won't have to wash it any more."—The Optimist.

Seen on an Excuse: Please excuse Helen for being absent, as she fell in the mud: and you will oblige by doing the same.—The Optimist.

Teacher: "What is man?"

Student: "A verse."

Teacher: "How so?"

Student: 'A unit of one or more feet is called a verse."—The Optimist.

CLASS STONES

Freshman—Emerald.
Sophomore—Rub(e)y.
Junior—Grindstone.
Senior—Tombstone.—The Optimist.

If the coefficient of friction of 10^{-6} along a frictionless plane, what is the coefficient of friction along a constant temperature plane?

That's peculiar, we saw a squirrel on the Commons bolting nuts!

Do you learn to raise anything besides whiskers in Biology? Nope, nothin' but raisin' cain. EX-SHEW!

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Our Reduction Sale Is Now On

Surely the best chance, you will have for a long time to get reliable goods at moderate prices.

Good staple goods, dyed with reliable foreign dyes. You know how acute the dye question has become. Our stock is entirely of foreign dyed goods—and is the choicest in quality and design that can be offered.

Again—the cost of woolens, trimmings—and everything in the clothing line is going up—bound to go higher. Look ahead—if you don't need anything now.

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SCHOOLROOM SCENE IN THE YEAR 1980

Teacher to new boy: "Hans, have you got your certificate of vaccination against smallpox?"

"Yes, sir."

"Have you been inoculated for croup?"

"Yes, sir."

"Have you had an injection of cholera baccilus?"

"Yes, sir."

"Have you a written guarantee that you are proof against whooping cough, measles and scarlet fever?"

"Yes, sir."

"And are you provided with your own drinking cup?"

"Yes, sir."

"Will you make a solemn promise never to exchange sponges with the other boys and never to use any pencil but your own?"

"Yes, sir."

"Do you agree to have your books fumigated with sulphur and your clothes sprinkled with chloride of lime once a week?"

"Yes, sir."

"Hans, I see that you fulfill all requirements of modern hygienics. Now you can climb over that wire, place yourself on an isolated aluminum seat and begin doing your sums.—Youth's Companion.

"DE" BAT(H)ING CLUB

Mrs. Maginnis: "Where have you been so late?"

Pat: "Debating Club."

Mrs. Maginns: "What; In winter?"—The Optimist.

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BOSTON YOUNG MEN'S CHRISTIAN ASSOCIATION

Special Terms for Non-Resident Students. Write for new illustrated catalog. Address:
312 HUNTINGTON AVE.

Teacher: "What is the name for nine meters."

Student: "Non-ameter."

Teacher: "Right; there is no such such meter."—The Optimist.

HEARD IN ALGEBRA CLASS

Teacher: "How much was the gross income of the fisherman."

Bright pupil from rear: "He had no gross; it was all net."—The Optimist.

Hers with the clocks on the stockings,
His with the hands on the clocks—
(Most scandalous, you will agree!)
But she hadn't them on—
Fact, they'd never been worn—
He was only the salesman, you see!—
Yale Record.

BABY'S PIN MONEY

Rosenstein took his wife and baby to the picture show, but while there the infant began to cry, and the Rosenstein family was requested to leave, the manager refunding the money.

Next week while at the same theatre, Rosenstein became bored.

"Do you like this show, Becky?" he asked his wife.

"No, it's bum," she replied.

"All right," said Rosenstein, getting his hat. "Stick a pin in the baby."—Knick Knacks.

Voice—Is this the Weather Bureau? How about a shower tonight?

Prophet—Don't ask me. If you need one, take it.—Chaparral.

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RUFF STUFF

She (pointing to a noted blood specialist)—Who is that distinguished looking man?

He—Oh, that's only a circulation manager.—Widow.

EVER GET ONE OF THESE INVITATIONS?

John—I'm going to have a swell feed in the room tonight.

George—I'll be there.

John—All right. Lend me a quarter to buy some crackers; you get some milk and cheese, and we'll have a rarebit.—Jack-o'-Lantern.

Bjones—I hear she's a budding debutante.

Bjornsen—I think she's a blooming idiot.—Gargoyle.

We pay our respects to the ten-cent phonograph record—the nearest approach to free speech we have ever heard.—Punch Bowl.

THE ANVIL CHORUS

For the purpose of knocking those that need knocking, especially the knockers.—Punch bowl.

"See the moon," said a lady to her nephew, a bright little boy of five, as they sat looking out of the window the other day. "The moon!" said thelittle man. "You can't see the moon in the daytime." "Yes you can," continued his aunt, "there it is over the trees." The little fellow had to admit that he saw it but added: "'tain't lighted anyway."—Teacher's News Letter.

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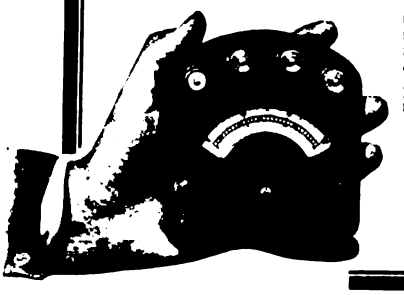

The group includes Portable Volt-Meters, Millivoltmeters, Volt-Ammeters, Ammeters, Mil-Ammeters in single, double and triple ranges; Battery Testers, and Switchboard Voltmeters, Volt-Ammeters, Ammeters and Mil-Ammeters. The several models and ranges offer a selection from over 300 different combinations.

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Boston	Cleveland	St. Louis	Toronto
Philadelphia	Cincinnati	Denver	Winnipeg
Buffalo	Richmond	San Francisco	Vancouver

First mother—Mrs. Clancy, yer child is badly spoiled.

Second mother—Gwan wid yez.

First mother—Well, if you don't believe it, come and see what the steam roller did to it.—Lampoon.

I am engaged to a pretty school teacher. What would you suggest for a suitable gift,—a chair or a table?

A school teacher would probably appreciate a multiplication table.—Michigan Technic.

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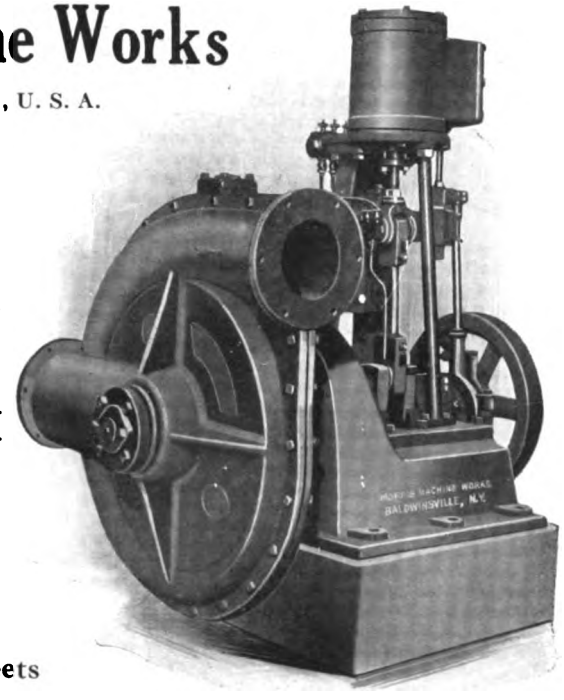

PROGRESS

"Where's that hotel that used to advertise, 'All the Comforts of Home for One Dollar'?"

"Busted up. The hotel opposite put up a sign: 'None of the Discomforts of Home for Two Dollars.'"—Boston Transcript.

Willie—Do you know everything, Pa?

Pa—Yes, my son.

Willie—What is the difference bebetween a son of a gun and a pop of a pistol?—Purple Cow.

Admiral (seeing enemy's ship sink)—Who fired that shot?

Old Salt—The ship's cook, sir; he got the range and stove in her side.—Sun Dial.

NOT PRECISELY WHAT HE MEANT TO SAY

The Girl's Mother—And do you think my daughter can live on your salary?

The Steady Company—Why not? Other women have.—Puck.

"Say, jeweler, why don't my watch keep good time?"

"The hands won't behave, sir. There's a pretty girl in the case."—Widow.

Referring to pocketbooks, most of us had our hollow days after December 30th.—Punch Bowl.

"How close a friend is he of Mabel's?"

"He had powder all over his coat last night."—Punch Bowl.

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THE PLAZA New York
THE GREENBRIER
White Sulphur Springs, W. Va.
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SLUGGISM

Given—My girl.
To prove—She loves me.
Proof:
She's all the world to me,
All the world loves a lover,
I'm a lover,
Therefore she loves me—Q. E. D.—Student.

Bob ran lightly up the steps and gave the door-bell an impatient yank. The door was opened by a new maid who had never seen the young man before.

"Is Miss Edith in?" he demanded.

"Yes, sor," said the girl; "but she's engaged, sor."

"Well" said Bob, "I'm what she's engaged to; let me in."—Ex.

TWO OF A KIND

1

Centralite: "Who's the head of your physics department?"

South Sider: "Ware."

C.: "In South Side."

S. S.: "I said Ware."

C.: "Well, where do you think I mean—in Egypt?"

2

First Student: "How is it that that man took away all the history books?"

Second Student: "Howe."

First Student: "What's how?"—The Optimist.

Is the Yale lock employed by students at New Haven when they go fussing?—Michigan Technic.

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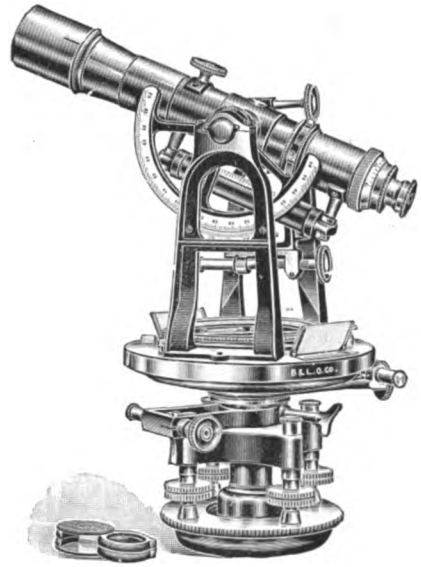

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Four-year old Johnny was crying because he had to leave the theatre, after merely seeing the show once.

"Be a good boy," coaxed Mama, "and when the ice-cream man goes by tomorrow I'll give you five cents."

"You give me five cents," sniffed Johnny, appeased, "and the tream man won't go by; he'll thop."—Ex.

"It's the little things in life that bother me."

"You bet—little things about 115 pounds!" (Business of dog look and nudging.)—Yale Record.

"Marriage is a lottery."

"Not with these cobweb clothes the women are wearing now."—Jack-o'-Lantern.

IA TEST PAPERS

"Infinite"—Defined and used.

1. Not completed—His work was done in an infinite manner.

2. Everlasting—He was an infinite boy.

3. Divine—His song was infinite.

4. A place beyond—The cave seemed to lead to infinite.

5. Below—He was infinite in his studies.

6. Below—The man rose from infinite ground to the beautiful earth.

7. Not an exact time—He told me to come at an infinite time.

8. Below the normal—The infinite boy was allowed to go.—The Optimist.

FORD JOKE

Blessed are the peacemakers for they shall see Europe.

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"Engaged to four girls at once?" exclaimed the horrified uncle. "How do you explain such shameless conduct?"

"I don't know," said the graceless nephew. "I guess Cupid must have shot me with a machine gun."—Ladies' Home Journal.

He—I'm debating with myself whether to go on a party after the game or not.

She—I bet you win.—Lampoon.

Ike—I am desirous of being introduced to a girl in the gas works. Could I go down the cellar to meter?—Michigan Technic.

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March 1916 Vol. II, No. 8

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BOSTON, MASS.

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is a sturdy, well-nourished baby.

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The Technology Monthly
and Harvard Engineering Journal

A magazine devoted to the interests of the Massachusetts Institute of Technology—The Official Organ of the Association of Harvard Engineers

Vol. II Contents March, 1916 No. 8

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Entered as second-class matter at the post office, at Boston, Mass. Published monthly during the college year by the students of the Massachusetts Institute of Technology. Publication office, Technology Union Building, 42 Trinity Place, Boston. Harvard Editorial Office, 218 Pierce Building, Cambridge, Mass.

Mail Address: Technology Monthly, M. I. T., Boston, Mass.
Phone Back Bay 58494

Subscription rate, $1.50 per year; 25c. per copy. Advertising rates upon application

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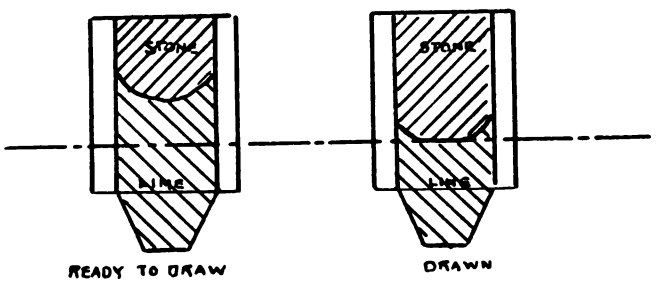

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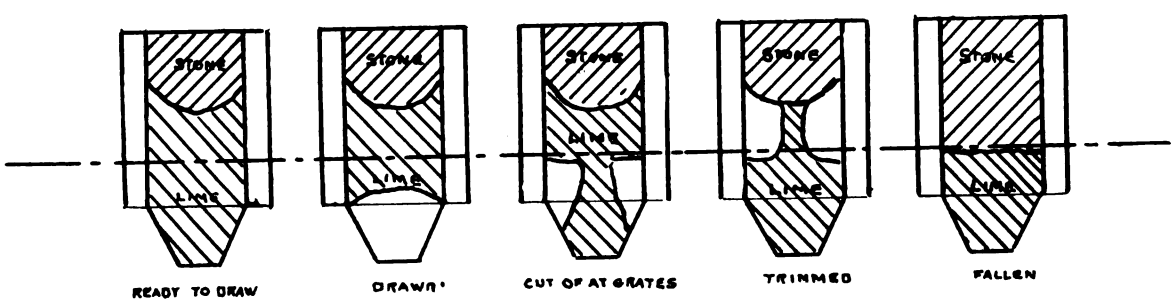

Vertical sections of shaft, showing method of operation of "sticking" process.

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THE TECHNOLOGY MONTHLY
AND HARVARD ENGINEERING JOURNAL

VOL. II BOSTON, MASS. MARCH, 1916 NO. 8

LIME, ITS MANUFACTURE AND INDUSTRIAL USES

By CHARLES H. ALBEE. M. I. T., '13
Chemical Engineer, Rockland and Rockport Lime Company

Editor's Note. One of the fundamental chemicals of present-day industry is lime. This is because lime is the cheapest base that we have. Here Mr. Albee tells you in a most thorough manner what you as a future engineer should know about the uses to which lime may be put.

ALTHOUGH the art of lime burning dates back to earliest antiquity, very little exact information regarding the subject is available. This may be due to the fact that lime is a cheap commodity, and in the past practically no attention has been paid to quality. With the development of the chemical industries new fields have been opened, in which quality is of the greatest importance. Contractors, builders and other consumers are slowly realizing that a cheap product and low cost are by no means synonymous.

On account of these facts and the demand which every industry has for higher economy, it has been necessary to study the properties of lime. In the following article I will endeavor to outline a few of the changes that have taken place in the methods of manufacture, the products that are produced and the properties which limes must have, in order to meet the various conditions under which they are used.

Limestone is the raw material upon which the manufacture of lime is based. It is of sedimentary origin and is defined by the National Lime Manufacturers Association as that class of rocks which vary in composition from pure calcium carbonate to a mixture of calcium and magnesium carbonates in the proportions of 54.35 and 45.65, respectively. Any graduation between these limits may be found, and all limestones contain more or less impurities, such as silica, iron and alumina. Aside from these chemical differences the stone may be classified according to its physical properties, as hard or soft, coarsely crystalline or fine-grained, porous or dense. The distribution of this material is very wide: there is hardly a state or territory in the Union in which limestone does not occur; in some it is the underlying strata and exists in great purity, while others are so poorly supplied they can never hope to become important producers.

Maine was one of the first states to burn limestone. It is less than one hundred years ago when Knox County produced and shipped lime to Norfolk, Wilmington, Charleston, New Orleans and points in the Middle West.

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In those days quarries were developed where there was practically no stripping. Rock was drilled and broken by hand. Mechanical power was not required, and the producer gave no thought to the subject. These methods were slow and tedious, and as the demand for lime increased and competition lowered the prices, new methods had to be devised. Steam was then introduced as a motive power. In driving quarry pumps, hoists and drills, long lines of piping were required, expensive in maintenance and loss of power. Some plants still use this method, but the more modern have undertaken electrification. The polyphase induction motor coupled to a turbine pump has proved to be a worthy successor to the steam driven piston or plunger type. Compressed air and Jackhamer drills have made it possible for one man to drill one hundred and eighty feet per day, as against sixty-five feet when two men operated a steam tripod drill, and as against thirty feet when one man drilled by hand.

The art of burning lime may be defined as the process of converting limestone into lime through the agency of heat. The dissociation temperatures of calcium and magnesium carbonates are 898 and 550 degrees centigrade, respectively. In the manufacture of lime it is first necessary to raise the temperature of the stone to its dissociation temperature, which varies according to its chemical properties; the time which this requires depends upon the physical nature of the rock. A fine-grained dense substance will conduct heat more readily and burn quicker than one which is coarsely crystalline and porous. In practice it has been found more economical to maintain as high a temperature as possible, in order to reduce the time required in burning, the upper limit being determined by the phenomenon of "over burning." "Over burned," lime is lime in which the impurities have entered into chemical combination with the calcium and magnesium. This can be recognized by its yellow color and its partly fused condition.

Compared with the complicated processes employed in the manufacture of Portland cement, lime making is a very simple industry. The types of kilns universally employed in its manufacture may be classified as given below. Several attempts have been made to adapt the rotary kiln, so well known in the cement industry, to lime burning.

a. Intermittent Kilns.

b. Continuous Kilns.

1. Vertical kilns with mixed feeds.

2. Vertical kilns with separate feeds.

Intermittent kilns are those in which each burning of a charge constitutes a separate operation. They are large rectangular boxes, rudely constructed of stone, open at the bottom for firing and at the top for charging. The largest pieces of limerock are first selected and formed into a rough dome-like arch, springing from the bottom of the kiln to a height of five to six feet. Above the arch the kiln is filled from the top, the larger pieces being used in the lower layers and the smaller ones higher up. A fire is now started under the dome, and the temperature gradually raised until the mass is a cherry red. This condition is maintained for three or four days. At the end of the run, the kiln is allowed to cool and the material is removed and sorted. Although this type is simple and cheap, it is extremely wasteful in heat and labor. Moreover, the quality of the lime produced is not uniform,—that nearest the dome is liable to be over burned, while the top por-

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tions of the charge are very seldom calcined.

The disadvantages of the intermittent kiln were partly overcome by the introduction of the vertical shaft kiln with a mixed feed. In general this type resembles a short wide stack, lined with a refractory material and having a casing of either steel or stone. Limestone and fuel are charged into the kiln in alternate layers. As the burning progresses, lime is drawn from the bottom and fuel and stone are added to the top. The advantages of this type are its initial low cost and operating expenses. Its product, while good enough for ordinary purposes, is not as evenly burned or as white as that produced in a "separate feed" kiln.

With the introduction of coal as a fuel, it was necessary to construct a kiln in which the clinkers would not render the fine lime unfit for use. This was accomplished by a separate feed kiln, the type now used by nearly all the manufacturers of lime. These kilns are essentially short wide stacks of either round, square or elliptical cross sections, ranging from forty to fifty feet in height, and having an outside diameter of about eleven feet, and an inside diameter varying from nine feet at the hopper to about five feet at the furnaces. For the convenience of discussion let us assume that these stacks are divided into three compartments. The top compartment, where the limestone is stored and pre-heated, is called the hopper. The middle compartment, which is directly over the furnaces and where the lime is calcined, is called the shaft. The third compartment, which lies below the furnace openings, is called the cooling cone. The furnaces, similar to the common fire boxes in use under boilers, are usually placed diametrically opposite. Fuel is burned on grates, and only the gases of combustion come into direct contact with the lime. In this way more accurate temperature control is obtained, and the lime is not discolored by intimate contact with the fuel.

Since the manufacture of lime is merely a heat treating process, many devices have been invented to regulate the temperature and better the fuel economy. Probably the most prominent of these is the Doherty-Eldred process, in which the gases of combustion, coming from the top of the kiln, are mixed with air and led under the grates of the furnaces. By proper regulation of these gases, the rate of combustion is so controlled as to give the required working temperature, and, as claimed by many, better fuel economy.

Wood is without doubt the ideal fuel for burning lime. Practical experience has shown that this material gives a larger capacity, a greater quantity of first quality lime and requires less care in the operation of the kiln than coal. On account of economic conditions, however, lime manufacturers have been forced, much against their will, to use coal as a fuel. It has been my experience that coal will produce as good a quality of lime as wood; the main difference between the two fuels seems to lie in the matter of quantity. The following table shows the kinds of fuel in use and the number of kilns using the various fuels, as reported by the Department of Interior in their pamphlet "The Production of Lime."

	1913	1914
Coal,	1334	1404
Wood,	479*	420
Oil,	54	47
Natural Gas,	30	36
Producer Gas,	76	86
Coke,	123	168
Shavings,	—	29
Coal and Wood,	220	157
Coal and Coke,	22	27
	2338	2374

*Includes 19 kilns using shavings.

There are two procedures in common

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use for operating lime kilns; one the following, and the other the sticking process.

When lime is drawn from the bottom of a kiln operated by the former method, the entire mass of lime and stone follows down, as would naturally be expected. In practice this operation is repeated until the unburned portions of stone are just above the level of the grates. The difficulty with this method is that lime will burn higher up on the sides of the kiln than it will in the centre. On account of this fact, the operator has his choice of either drawing small quantities of unburned stone into the cooling cone, or leaving previously burned lime in the fires for a second burning, with the chance of "overburning" the product.

The difficulty just explained may be obviated by employing the sticking process. This method consists of slightly cooling the kiln, just before drawing, until the entire mass sticks to the sides of the shaft. When lime is now withdrawn from the cooling cone, and that portion remaining in front of the fires is punched down by means of long iron bars, the rock falls even and level with the grates. The details of the two methods are shown by the accompanying sketches.

In classifying limes and reviewing their general properties, I can do no better than quote from recent government publications.

"A consideration of the burning process as just described shows that lime is merely limestone from which the carbon dioxide has been removed by heat. This, then, must constitute a definition of lime. The wide variation in the chemical and physical properties of limestone necessitates a similarly great difference in the kinds of lime. Therefore, some system of classification becomes necessary." The National Lime Manufacturers' Association has officially adopted a classification based on the content of magnesia as follows:

High-calcium lime contains	0% to 5%	magnesia
Magnesian lime	"	5% " 25%	"
Dolomitic lime	"	25% " 45%	"
Super-dolomitic lime	"	over 45%	"

Since lime has such an indefinite commercial meaning, any description of properties must be very general. There are, however, several properties which are common to all limes in a greater or less degree. Thus it may be said that lime is a white or nearly white substance which will slake when water is added to it. When lime slakes, it enters into chemical combination with the water. This reaction generates heat, and is accompanied by an increase in volume. Slaked lime when exposed to air will set. First the excess water evaporates, and then carbon dioxide from the air attacks the lime, converting it back to the original calcium carbonate. Setting is always accompanied by a decrease in volume, or shrinking.

The degree in which any lime possesses the above properties is more or less dependent on its chemical composition. For example, a dolomitic lime will slake more slowly, combine with less water, generate less heat, undergo less increase in volume, set more slowly, and shrink less than a high-calcium lime. This statement must be taken as a generalization, for the properties are decidedly influenced by the impurities, the temperature of burning, and many other factors.

When lime is exposed to the air it absorbs carbon dioxide and water and "air slakes." This reaction takes place in two more or less distinct stages, first, the absorption of water, and second, the displacement of the water by carbon dioxide.

The absorption of water during the

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process of air slaking involves a large increase in volume, and therefore the lumps fall to pieces. This fact gave rise to the demand for "lump lime," the consumer being of the opinion that all fine lime is air slaked. There are however, several grades of limestone which fall to pieces in the kiln. The stone may be so soft that it is broken up by the abrasion; it may have its pores filled with water, which when heated shatters the stone; or its component crystals may be bound together by organic matter which is consumed in the kiln. Stones like these are being burned, and in some cases over 50 per cent of the output of the kiln is fine stuff. Such fine lime is as good for all purposes as lump lime, and it is easier to handle and will keep better. This is obvious from the consideration that the top layer of a pile of fine lime will air slake, and the crust of inert material so formed will prevent access of the air to the quicklime underneath. The old prejudice against fine lime is rapidly losing ground, as is shown by the fact that some manufacturers are putting crushed lime on the market. The better keeping qualities of this product are being taken advantage of by some firms, who ship the fine lime in open gondola cars.

Hydrated lime is a product recently put on the market to take the place of lump lime. As its name indicates, it is lime which has already been hydrated; that is, the chemical combination with water has already taken place. It is a fine, dry, white powder, which is shipped in paper or burlap bags, and which may be used for any purpose instead of lump lime.

The chief advantages to the consumer of hydrated lime are as follows: It can be handled more easily on account of its being in powder form. It will keep better than lump lime for the reasons just noted. It does not require slaking, but must merely be soaked in water to prepare it for use. This saves time and labor and eliminates any danger of loss of lime due to unskilled slaking. Any unburned or overburned lime which has passed the sorter will not hydrate, and can be screened out of the finished product. Hence, hydrated lime should contain less refuse than lump lime. On the other hand, hydrated lime contains 15 to 25 per cent of water, on which the consumer must pay the freight.

Manufacturers reap several advantages from the operation of a hydrate mill. It gives them a product which can be stored, so that in case the orders for lump lime decrease unexpectedly the lime can be hydrated and stored, and the kilns need not be shut down.

The most marked feature of the lime industry since 1906 has been the rapid growth in the production of hydrated lime, which in 1913 had increased over 400 per cent in both quantity and value. Its price per ton has fluctuated between $3.98 and $4.69 per ton, and was highest in 1907. During the four years, 1911 to 1914, inclusive, its average price has been $4.43 per ton. The following table shows the quantity and value of hydrated lime produced and sold in the United States from 1906 to 1914, inclusive, together with the average price per ton and the total number of manufacturers reporting:

Year	Quantity	Value	Average Price per ton	Plants Oper'ng
1906	120,357 tons	$479,079	$3.98	30
1907	140,135 "	657,636	4.69	32
1908	136,411 "	548,262	4.02	46
1909	204,611 "	904,900	4.43	50
1910	320,819 "	1288,789	4.02	51
1911	304,593 "	1372,057	4.50	60
1912	416,890 "	1829,064	4.39	64
1913	493,269 "	2205,657	4.47	80
1914	515,121 "	2239,916	4.35	82

Lime is used for a great variety of purposes. The principal uses, as far

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as it is possible to give them, are shown in the following table, which is made up from data furnished by the manufacturers throughout the United States. Under the head of "Dealers—uses not specified" is included a considerable quantity of lime which would necessarily raise the figures for all the other products, but the manufacturers were not able to classify the figures given under the heading.

	1914 Quantity	Value	Average price per ton
Building lime,	1,163,433 tons	$5,047,113	$4.34
Chemical works,	367,497 "	1,202,178	3.27
Paper mills	242,998 "	915,369	3.77
Sugar factories,	31,931 "	187,605	5.88
Tanneries,	43,793 "	190,253	4.34
Fertilizer,	689,948 "	2,161,844	3.13
Dealers—uses not not specified,	646,490 "	2,791,139	4.32
Other uses,*	194,838 "	752,175	3.86
Total	3,380,928 tons	$13,247,676	$3.92

*Includes lime for sand lime brick, slag cement, alkali works, steel works, gas works, smelters, sheet dipping, disinfectant, manufacture of soap, cyanide plants, glue factories, purification of water, etc.

As can be seen from the above table the greatest use of lime is as a mortar for building purposes. Whether a dolomite or high-calcium lime is best suited for this purpose has long been an important question for both lime manufacturers and builders. However, it seems to be the consensus of opinion that dolomitic limes are best for finishing purposes, while high-calcium limes are used in brick work, scratch and brown coats in plastering, and wherever strength is required.

For both building and plastering purposes, hydrated lime may be used interchangeably with quicklime and is often preferred, especially for the final coat in plastering. Hydrated lime when used in concrete, is without question the most effective, permanent, yet most inexpensive waterproofing material on the market. It is of a mineral base, and when used in this way it is there to stay as long as the structure stands. It has been found that when hydrated lime is added to concrete up to 15 per cent by weight of the cement, it does not materially affect the strength of the mortar, even when poured under water. In a test of waterproofing materials conducted by the Bureau of Standards in 1910, in which forty materials were used, they reported as follows: "This (referring to hydrated lime) is the most effective medium employed and resulted in an almost impermeable mortar at the two week test. Its value is probably due to its void-filling properties." Therefore, hydrated lime is a product of great intrinsic value and one that can be used with utmost safety in concrete work for the purposes named above.

Sand-lime brick, although a rather new material, is of some importance in the building industry. The process of manufacture consists in forming bricks of a mixture of sand and hydrated lime by means of hydraulic pressure. The bricks are then treated with high-pressure steam, which causes chemical combination between the sand and lime. The lime may be hydrated before or after adding the sand, but hydration must be complete before the bricks are pressed, in order to prevent any further change of volume. High calcium lime is preferable to magnesian lime, because there is less danger of incomplete hydration, and it produces a stronger brick. The impurities generally present are not harmful, except in so far as they may cause the lime to slack more slowly. In fact, kaolin, up to 2½ per cent, may be considered beneficial. Hydrated lime is to be preferred to quicklime because it is more easily mixed with the sand.

Calcium oxide is a necessary constituent of plate, sheet, and bottle glass, and of a large portion of pressed and blown glass. It acts as a flux. Magnesia makes the glass more difficult to melt, but it is sometimes a valuable

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constituent when particular optical properties are to be obtained. The calcium oxide is generally introduced as ground limestone, but in this industry, also, the use of lime or hydrated lime is sometimes necessary in order to avoid the evolution of gas at high temperatures. The ordinary impurities of limestone are, in general, of no importance to the glass manufacturer. For white glass, however, the content of oxide of iron must be less than three-tenths of one per cent of the stone.

Most of the soda ash sold in this country is made by the "ammonia soda" process. A solution of common salt is saturated with ammonia, and the mixture is treated with carbon dioxide. When the resultant solution is evaporated, the soda ash is obtained by crystallization. Ammonia is expensive, and consequently the gas must be recovered and used over again. For this purpose the mother liquor is treated with lime and distilled. The lime replaces the ammonia in its compounds and thus the gas is set free to distill off. It is evident that this industry demands limestone, for both the lime and the carbon dioxide are used. The impurities in the stone are not harmful. It would seem that magnesium oxide should be as effective as calcium oxide in breaking up the compounds of ammonia, yet Lunge makes the statement that "magnesian limestone is not suitable for this industry."

Caustic soda is made by dissolving soda ash in water and adding lime. Insoluble calcium carbonate is precipitated, and caustic soda is left in solution. In this reaction, the magnesia is entirely inert. The impurities are undesirable, because they form a gelatinous precipitate which does not settle clear, and therefore leads to a contamination of the finished product. In this industry quicklime is preferable to hydrated lime because it hastens the reaction.

Bleaching powder is an oxychloride of calcium which is formed by the action of chlorine gas on moist slaked lime. The resultant product is sold on the basis of available chlorine. Any impurities in the lime will lower the amount of chlorine absorbed, and consequently the value of the product. Magnesia is especially objectionable because it forms magnesium chloride. This substance absorbs water from the air and makes the powder sticky and hard to handle. Hydrated lime is better suited for this industry than quicklime, because it contains fewer impurities, is easier to handle, and requires no preparation before using.

Calcium carbide, the source of acetylene, is made by heating a mixture of lime and coke in an electric furnace. For this purpose, the only useful ingredient of the lime is calcium oxide. Magnesia and other impurities are objectionable because the whole charge must be fused, and electric power is too expensive to waste it by heating useless material. For the same reason, quicklime is preferable to either hydrated lime or limestone.

When illuminating gas is made by the distillation of coal, the crude product contains, among other compounds, carbon dioxide, hydrogen sulphide, and hydrocyanic acid. All of these would be objectionable to the consumer Their removal may be effected by passing the gas through layers of moist slaked lime. For this purpose calcium oxide only is useful, although the magnesia and impurities are not harmful. Hydrated lime is to be preferred to quicklime, because it is easier to handle and requires no preparation. Crude coal gas is the chief source of ammonia. This is

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removed by washing the gas with water before it has reached the lime purifiers. The solution thus obtained carries both free ammonia gas and some compounds of ammonia. The free gas is driven off by heat and collected. Lime is then added to break up the compounds, and the ammonia thus liberated is also distilled and collected. Calcium and magnesium oxides should act with equal facility in liberating the ammonia, but, according to Lunge, magnesium limestone is not applicable to this industry. The impurities are not harmful. Either quick or hydrated lime may be used, with little advantage in favor of either.

Calcium cyanamide and calcium nitrate, known technically as "lime-nitrogen" and "nitrate-lime," have recently been put on the market as commercial fertilizers. They represent means of converting the nitrogen of the air into plant food. Calcium cyanamide is prepared by heating a mixture of lime and coke in an electric arc furnace, and treating the fused mass with nitrogen. The nitrogen is obtained from the fractional distillation of liquid air. Pure, high-calcium quicklime is required for this industry. Any impurities are undesirable on account of the expense required to heat them. If air is passed through an electric arc, the nitrogen and oxygen contained in it will combine. The oxide of nitrogen thus formed, when dissolved in water, produces nitric acid. This will combine with any base to form the corresponding nitrate. Since lime is the cheapest of all bases, and has a fertilizing value of its own, it is obviously the base to use. Hence calcium nitrate is formed. Magnesia acts in a similar manner, and its use is dependent on whether or not it would be harmful as a fertilizer. The presence of impurities in the lime is a matter of indifference and quicklime, hydrated lime, or limestone will produce identical results. Hydrated lime is probably the most economical.

Lime is used extensively as a fertilizer. The Department of Agriculture and the various State agricultural experimental stations have carefully investigated the use of lime for this purpose, and have published their conclusions in several bulletins.

In the manufacture of sugar, both carbon dioxide and lime are used; therefore, the sugar manufacturers prefer to buy limestone and burn their own lime. The juice extracted from either beet or sugar cane contains various impurities. Some of these would discolor the sugar, and others (organic acids) would invert it. That is, they would change the sugar into uncrystallizable glucose, and thus reduce the yield. In order to remove these impurities, the juice is heated almost to boiling in the presence of an excess of lime. This combines with the acids, and breaks up the other organic compounds forming insoluble salts. But it also forms an insoluble compound with the sugar itself. For this reason after the lime has completed its action, carbon dioxide is forced into the liquid. This breaks up the combination between the lime and sugar, and throws down all the lime as calcium carbonate. The precipitate carries with it all suspended matter, leaving a clear solution of sugar. For the above purposes calcium oxide only is useful. Impurities are apt to cause trouble. Thus, magnesium carbonate is more soluble in sugar solutions than calcium carbonate, and the salt so dissolved is later deposited on the tubes in the evaporating pans, thus making it necessary to clean them more frequently. Any silica present is thrown down as a gelatinous precipitate. This becomes

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a general nuisance by coating the cloth in the filter presses.

The destructive distillation of wood gives rise to four products: gas, pyroligneous acid, tar and charcoal. Of these, pyroligneous acid is of most interest to the lime manufacturer. From this solution are prepared wood alcohol, acetic acid and acetone, and lime is an essential ingredient in the manufacture of all of these. First, the crude acid is treated with an excess of lime and distilled. Good alcohol passes over, but both acetic acid and acetone are held in the still in chemical combination with the lime. This mixture is known as "gray acetate of lime." Acetone may be produced from it simply by dry distillation; or it may be treated with sulphuric acid, and the acetic acid distilled off. The wood alcohol is again treated with lime and redistilled in order to purify it. For any of the above purposes, calcium oxide is the only useful constituent of the lime. Magnesia and impurities are not harmful. Hydrated lime may be used instead of quicklime for any of the above purposes, except final distillation of the wood alcohol. For the other purposes, probably neither substance has any advantage over the other.

Wood pulp, for the manufacture of paper is prepared by one of three processes: mechanical, soda, or sulphite, of which only the second and third interest the lime manufacturer. In the soda process lime is used to causticize sodium carbonate, thus recovering the caustic soda used in cooking the wood. Calcium oxide is the only constituent of the lime useful in the soda-pulp industry. The magnesia and impurities are not harmful. Hydrated lime may be used instead of lump lime, but the latter is to be preferred, since the heat generated by its slaking hastens the reaction with the soda. Another solution which may be used in place of caustic soda for dissolving the cementing constituents of wood is "bisulphite liquor." This is a mixture of calcium and magnesium bisulphites held in solution by an excess of sulphur dioxide. The liquor is prepared by one of two methods. Limestone may be subjected to the solvent action of sulphur dioxide and water, or milk of lime may be treated with sulphur dioxide. The resultant solution is the same in either case. For the maker of sulphite pulp, magnesia is a desirable constituent of the lime or limestone. Magnesium sulphite is more soluble than calcium sulphite, and consequently permits of making a stronger liquor. Moreover, the presence of magnesia in the liquor gives the pulp a better color and makes it softer to the touch, so that it will felt together better when made into paper. Therefore, dolomite, or magnesian lime, is much preferable to the high calcium compound. The impurities are not harmful. If limestone is used, it should be as porous as possible to permit of rapid solution. Hydrated lime is preferable to lump lime, because it is easier to handle and contains fewer impurities.

Ground lime, air slaked lime, levigated chalk (natural whiting), and chemically precipitated calcium carbonate are used to a large extent in the paint and allied industries. For these purposes, fineness of grain is essential, while sometimes the color or chemical composition is of equal importance. It is generally impossible to obtain a limestone of sufficient whiteness, or to grind it sufficiently fine to meet the requirements. It is, therefore, an advantage to use air-slaked lime, or hydrated lime. Cold-water paints consist essentially of hydrated lime, pigments and

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casein ground together. From the nature of the substances, it is obviously impossible to use quicklime, and magnesian hydrates are probably to be preferred over high calcium hydrates on account of their better spreading qualities.

Most of our common fats are compounds of glycerin with various organic acids. These compounds can be broken up by heating the fat with lime and water under pressure. The glycerin is liberated, while the lime takes its place in the compounds. Practically all of the glycerin used in this country (mostly in the manufacture of explosives) is made in this way. The lime "soaps" formed by this process are sometimes mixed with heavy mineral oils, and sold as lubricants or greases. They are of especial value for the lubrication of heavy machinery, or for use at high temperatures. Or, the soaps may be treated with sulphuric acid. The separated fatty acids are recovered and used in the manufacture of soap and allied products. Calcium oxide is the only useful constituent of the lime, although the magnesia and impurities are not harmful. Quick lime is probably preferable to hydrated lime, because the heat of slaking can be used.

In the leather industry lime is used in the "depilation" process. The hair is so loosened from the hide by soaking it in lime water that it can be removed by subsequent scraping. In regard to the quality of lime to be used, the following statement is made: "The presence of magnesia and clay is injurious, not only by diminishing the amount of lime present, but by making the lime much more difficult to slake; and iron oxide, though quite insoluble, may become mechanically fixed in the grain of the hide, and may be the cause of subsequent stains." The use of hydrated lime would remove the above objections to magnesia, but not those to iron. Hydrated lime is probably preferable to quicklime for this reason, as well as for the fact that it is easier to handle.

The uses of limestone and its products are so numerous that it would be practically impossible to discuss them all. However, those mentioned above include those which are of the greatest commercial importance.

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CORRELATION BETWEEN TENSILE AND BENDING TESTS OF CAST IRON

By WINSLOW H. HERSCHEL, H. U., '96
Assistant Physicist with the Bureau of Standards

Editor's Note. The first part of this, Mr. Herschel's thorough discussion of the Correlation between Tensile and Bending Tests of Cast Iron, appeared in the February, 1916, issue of The Technology Monthly and Harvard Engineering Journal. This is the conclusion of his treatise.

OUR problem is, however, not completely solved, until we have found the relation between a change in the value of one variable, and a corresponding change in the value of the other. As shown in Fig. 3, the means M_x and M_y intersect at the point M, and the lines RR and CC also pass through this point. These last two lines are called the lines of regression. A point on the line RR is obtained by plotting a value of Y, used to designate a row in Table III, against the average value of X in the row, as given in col. 21 of the table. On the other hand, a point on the line CC is obtained by plotting the average value of Y in a column, as given in row 18 of the table, against the value of X used to designate a column. For example, the cross which is furthest to the right of Fig. 3, shows that col. 20, for the class with a mean value of 44,000 lbs. per sq. in. tensile strength, corresponds to an average value of center load of 4270 lbs.

The lines of regression might be drawn by averaging points by means of a black thread, but this method is objectionable because no two experimenters would locate the lines alike, when using the same data, and it would be difficult to give points near M, which depend upon a larger number of observations, a proper weight as compared with scattered points further away. The method we shall use gives the most probable location of the lines by the theory of least squares, the only assumption being that it is proper to use a straight line. On this point Yule[8] says, "it is found either (1), that the means of arrays (i.e. either rows or columns) lie very approximately around straight lines, or (2), that they lie so irregularly (possibly owing only to paucity of observations) that the real nature of the curve is not clearly indicated, and a straight line will do almost as well as any more elaborate curve" It would therefore seem that the intricate methods of Pearson[9] and Blakeman[10] need only be used in cases where great accuracy is desired, and a great abundance of observations are available.

In Fig. 3, $\tan kMl = b_1 = -\frac{r\,\sigma_x}{\sigma_y}$ and this value is called the regression of X on Y and represents the deviation in X corresponding on the average to a unit change in the value of Y. Similarly, $\tan rMs = b_2 = \frac{r\sigma_y}{\sigma_x}$ is called the regression of Y on X. We should then have the equations,

$$d_x = -\frac{r\,\sigma_x}{\sigma_y}\, d_y \qquad (4)$$

$$d_y = -\frac{r\,\sigma_y}{\sigma_x}\, d_x \qquad (5)$$

8. *loc. cit. p. 169.
9. Karl Pearson, especially "On the general Theory of Skew Correlation and Non-linear Regression." Drapers' Co. Research Memoirs: Biometric Series II. Dulau & Co., London, 1905. Yule, p. 208, gives references to articles which are useful for the fitting of curves in cases of non-linear regression.
10. J. Blakeman, "On Tests for Linearity of Regression in Frequency Distributions." Biometrika Vol. IV., 1905, p. 332.

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TABLE V

X=Textile strength, in thousands of lbs. per sq. in.

Y=Deflection at instant of Rupture, inches.

Class	25	26	27	28	29	30	31	32	33	34	3	36	3	38	39	40	41	42	43	44	Av. X	f	dy'	fdy'	f (dy')2
0.081								1								1					36 000	2	−14	28	392
.084																	1				41,000	1	−13	13	169
.087	1																				25,000	1	−12	12	144
.090										1					1						36,500	2	−11	22	242
.093														1							38,000	1	−10	10	100
.096									1												33,000	1	−9	9	81
.099				1		1				1			2	2	1	2					36,100	10	−8	80	640
.102										1	1	1		1		2	1				37,700	7	−7	49	343
.105									1	1	1		1								34,900	4	−6	24	144
.108									1						1	2	1				38,600	5	−5	25	125
.111					1		1			1	1	5	4	1	1	2	1			1	36,800	19	−4	76	304
.114							1	1				3	4		2	1	1	4			38,000	17	−3	51	153
.117							1			1	1		1	1	2		1		1		38,600	9	−2	18	36
.120									1		1	2	1	2	6	1	1	2			38,400	17	−1	17	17
.123								1	2	1			3	2	2	2	1			1	37,500	15		−434	0
.126								1			1	2	1	1	2	1	1	2			38,100	12	+1	12	12
.129							1				1	2	3	3	6	3	1	1			38 100	21	+2	42	84
.132						1						1	2		2					1	37,400	7	+3	21	63
.135														1	1		1				39,300	3	+4	12	48
.138											1										35,000	1	+5	5	25
.141							1		1		1	2	3	1							35,600	9	+6	54	324
.144												1									36,000	1	+7	7	49
.147									1												33,000	1	+8	8	64
.150													1								37,000	1	+9	9	81
.153																		1			42,000	1	+10	10	100
.156																					—	0	+11	0	0
159										1	1							1			37,000	3	+12	36	432
.162						1									1	1					36,300	3	+13	39	507
.165																					—	0	+14	0	0
.168																					—	0	+15	0	0
.171													1								37,000	1	+16	16	256
Av Y	.087	—	—	.099	.111	.131	.122	.111	.120	.113	.125	.121	.123	.119	.122	.115	.115	.126	.117	.122				+271 −434	
	1	0	0	1	1	3	5	4	8	8	10	19	27	16	28	18	11	11	1	3	Totals	175		−163	4935
dx'	−12	−11	−10	−9	−8	−7	−6	−5	−4	−3	−2	−1		+1	+2	+3	+4	+5	+6	+7					

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for lines RR and CC respectively. It is however, more convenient to express these equations in terms of X and Y instead of in terms of the deviations. In our case we have $d_x = X - M_x = X - 37{,}325$ and $d_y = Y - M_y = Y - 4117.7$. Substituting in equation (4) for RR, we have

$$X = 4.78\,Y + 17{,}600 \qquad (6)$$

and similarly, from equation (5) for the line CC

$$Y = 0.0328\,X + 2890 \qquad (7)$$

The lines of regression in Fig. 3 have been plotted from these equations. It should be noted that while r is a pure number and its value is not affected by the scales in which d_x and d_y are measured, the standard deviations cannot be expressed in class intervals, but must be expressed in the units in which X and Y are measured, that is, in the present case, in lb. per sq. in., and lb. respectively. Equations (6) and (7) may be checked by noting that for either of them, if $X = 37{,}325$, Y is approximately 4118, so that the lines of regression pass through the point M. Also $b_1 = 4.78$, although it appears as 0.478 because the scale of Y is 10 times as large as the scale of X; and likewise $b_2 = 0.0328$ and appears as 0.328 on the Figure.

Although Tables I and II do not contain data for plotting points for ine RR separately from points for line CC, yet we have values for all the quantities entering into equations (4) and (5) and so may determine equations for the lines of regression. By substituting the proper values and simplifying, we have,

$X = 6.07\,Y + 9750$ for RR in Fig. 1. (8)

$Y = 0.1045\,X + 360$ for CC in Fig. 1 (9)

$X = 93{,}800\,Y + 22{,}250$ for RR in Fig. 2. (10)

$Y = 0.000001820\,X + 0.0508$ for CC in Fig. 2 (11)

It will be noted that the lines of regression lie in the second and fourth quadrants in Fig. 1 and 2, instead of in the first and third, as in Fig. 3, but this is merely due to the inversion of the scale of Y.

It follows from equations (6) to (9) that there is not a constant ratio between tensile strength and transverse breaking load, as assumed by Nagel. Equation (7) shows that a rise of 1 lb. per sq. in. in tensile strength means on the average a rise of 0.0328 lb. in center load, while from equation (6) a rise of 1 lb. in center load means on the average a rise of 4.78 lb. per sq. in. in tensile strength. In the first equation X is the independent variable, or as Davenport calls it, the subject, while Y is the relative. In equation (6), on the other hand, Y is the independent variable. Which equation should be used depends on whether the problem is to predict X from observations of Y, or Y from observations of X. In the case of tests of cast iron, it would usually be required to predict the tensile strength from bending tests, so that Y is the independent variable, and X the relative, and equation (6) applies. As shown in Table III, X varied from 25,000 to 44,000, and using these values in equation (6), Y varies from 1550 to 5520, or X/Y would range from 16.1 to 7.98. These are probable values or general tendencies indicated by the 175 tests of Table III, and any single test might show a widely different result, cast iron not being a very homogeneous material.

Having now completed the description of the method of correlation, we may apply it to determining whether deflection or center load is the better criterion for tensile strength. The calculation of average values of X and Y, as in col. 21 and row 18 of Table III, is not a necessary part of the method and merely serves as a rough check, but these

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averages are given in Tables V and VII. Keeping X equal to the tensile strength, as in Table III, we shall let Y equal the deflection at the center of the bar at the instant of fracture, that is, Y is taken as the maximum deflection of the bar, in inches. We shall then have a new correlation table, No. V, and Table VI for finding the mean product, p. From the totals of Col. 5 and 6, of Table VI, $+134/175 = 0.764 = \acute{p}$. From the total of fd'_y of Table V, we have $-163/175 = -0.932$ class intervals or -0.0028 in. The assumed mean value of the deflection, as indicated by the heavy lines in the Table being 0.123, we have for the true mean, My $= 0.123 - 0.0028 = 0.1202$ in. From the total of the last column of the table, we have $\sigma_y = \sqrt{\frac{\Sigma(d^2}{N} - (0.932)^2} = 5.23$ class intervals or 0.01569 in. Since X is the same as in Table III, $\delta^x = 3.28$ as before. For the same reason we have omitted the rows for $f\,d'_x$ and $f(d'_x)^2$ from Tables V and VII. The deviation products, needed in Tables VI and VIII, have also been omitted for the sake of simplicity. We may now correct p and have $p = \acute{p} - (0.932 \times 0.325) = 0.764 + 0.302 = 1.066$. Then from equation (1) $r = \frac{1.066}{5.23 \times 3.28} = +0.062$. The probable error is found to be 0.0508, so that the coefficient of correlation is but little in excess of the probable error and there is no certain indication of correlation.

By substituting in equation (4) and (5), we have,

$X = 36{,}098 + 10{,}200\ Y$ for RR

$Y = 0.1115 + 0.000000234\ X$ for CC

and the lines of regression in Fig. 4 were drawn with the help of these equations. It will be noted that the angle between the lines RR and CC is much greater than in Fig. 3. If two variables are entirely independent, RR will be vertical and CC horizontal. If each

TABLE VI

1 Deviation product	2 Plus	3 Frequencies Minus	4 Total	5 Products, col. 1 x col. 4 Plus	6 Minus
1	3	4	— 1		1
2	6	10	— 4		8
3	4	2	+ 2	6	
4	15	5	+10	40	
5	2	3	— 1		5
6	7	4	+ 3	18	
7	1	2	— 1		7
8	3	4	— 1		8
9	0	1	— 1		9
10	1	3	— 2		20
12	3	6	— 3		36
14	1	0	+ 1	14	
15	1	6	— 5		75
16	1	2	— 1		16
18	2	0	+ 2	36	
20	1	1	0		
21	2	3	— 1		21
22	0	1	— 1		22
24	3	4	— 1		24
26	1	0	+ 1	26	
28	0	2	— 2		56
32	1	1	0		
33	1	0	+ 1	33	
36	1	2	— 1		36
39	1	0	+ 1	39	
42	0	1	— 1		42
50	1	0	+ 1	50	
52	0	1	— 1		52
56	1	0	+ 1	56	
60	1	0	+ 1	60	
70	1	0	+ 1	70	
72	1	0	+ 1	72	
92	0	1	— 1		92
144	1	0	+ 1	144	
Total	67	69		664	−530
				530	
				+134	

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TABLE VII

X=Tensile Strength, in thousands of lbs. per sq. in.

Y=Deflection for load of 3300 lbs., inches

Class	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	Av. X	f	dy'	fdy'	f(dy') 2
0 0585																1					40,000	1	−10	10	100
.0605														1			1			1	41,000	3	−9	27	243
0625																	1	1			41,500	2	−8	16	128
.0645													2								37,000	2	−7	14	99
.0665							1	1								1		1			36,300	4	−6	24	144
.0685						1						1				1			1		37,300	4	−5	20	100
.0705													1	1	2	4	2				39,500	10	−4	40	160
.0725									2		1	2	2	1	4		3	2			38,100	17	−3	51	153
.0745							1						1	1	2	1	1	1			38,400	8	−2	16	32
.0765										1		2	3	1	2	2		2		1	31,500	14	−1	14	14
.0785									1	3		2	2	4	7	4	2	1			38,100	26		−232	
.0805	1				1	1					1	3	2		1		1				34,600	11	+1	11	11
.0825										1	1	1	1	1	2	1					37,300	8	+2	16	32
.0845								1			2	3	4	2	1	1					36,600	14	+3	42	126
.0865								1	3			1	2	2	3						36,200	12	+4	48	192
.0885				1			1			2	2	1	2	1	1	1		1			35,800	13	+5	65	325
.0905							1	1	1		1	1	1	1	2	1					36,000	10	+6	60	360
.0925																		1		1	43,000	2	+7	14	98
.0945													1					1			39,500	2	+8	16	128
.0965									1	1		1	2								35,400	5	+9	45	405
.0985							1				2				1						35,000	4	+10	40	400
.1005													1								37,000	1	+11	11	121
.1025																					—	0	+12	0	0
.1045																					—	0	+13	0	0
.1065																					—	0	+14	0	0
.1085																					—	0	+15	0	0
.1105												1									36,000	1	+16	16	256
.1125						1															30,000	1	+17	17	289
Av. Y.	.0805	—	—	.0885	.0805	.0871	.0837	.0820	.0838	.0835	.0868	.0829	.0821	.0795	.0800	.0757	.0721	.0778	.0685	.0765				+491	
																								−232	
f	1	0	0	1	1	3	5	4	8	8	10	19	27	16	28	18	11	11	1	3	Totals	175		+169	3916
dx'	−12	−11	10	−9	−8	−7	−6	−5	−4	−3	−2	−1		+1	+2	+3	+4	+5	+6	+7					

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variable is a function of the other, and is not influenced by any other variable, the lines of regression will coincide, and the problem becomes merely one of curve fitting, that is of finding the equation of a curve which will pass through a series of experimentally determined points. Most cases of statistics lie between these two extremes, the lines of regression making an acute angle with each other as in Fig. 1 to 5, the sharpness of the angle indicating the extent to which one variable is influenced by the other.

Theoretically, the deflection should be $\delta = \frac{Pl^3}{48 E I}$ (12). Since we have found that P does not have a constant ratio with the tensile strength, S, the deflection is a function of two variables, P and E, and it consequently would not be expected to show a marked correlation with S. One of the variables, the center load, P, may be eliminated by taking readings of deflection at a certain load, and in the tests which we have been using, a load of 3300 lb. was selected since the specifications provide that this shall be the minimum breaking load. Substituting this value in equation (12) we have, $\delta = \frac{995{,}000}{E}$ (13) which shows that S would be constant unless E varied with S. In making this calculation it must be assumed that the elastic limit is not reached. Whether or not this is permissible is difficult to decide, as the elastic limit of cast iron is an elusive quantity.

Table VII shows the correlation between tensile strength, X, and deflection due to load of 3300 lbs., taken as Y, and proceeding as before we get Table VIII from which to calculate the mean product, p.

TABLE VIII

1 Deviation product	2 Frequencies Plus	3 Frequencies Minus	4 Total	5 Products, Plus	6 col. 1 x col. 4 Minus
1	2	4	— 2		2
2	2	5	— 3		6
3	5	6	— 1		3
4	5	5	0		0
5	2	3	— 1		5
6	4	9	— 5		30
7	0	2	— 2		14
8	3	4	— 1		8
9	1	2	— 1		9
10	1	3	— 2		20
12	5	9	— 4		48
15	1	6	— 5		75
16	0	6	— 6		96
18	1	1	0		0
20	1	3	— 2		40
24	0	1	— 1		24
25	1	0	+ 1	25	
27	0	1	— 1		27
30	1	5	— 4		120
32	0	1	— 1		32
35	2	0	+ 2	70	
36	1	3	— 2		72
40	1	1	0		0
45	0	1	— 1		45
49	1	0	+ 1	49	
60	0	1	— 1		60
63	0	1	— 1		63
119	0	1	— 1		119
Totals				+144	—918
				—918	
				—774	

From col. 5 and 6 of Table VIII we have $-774\ 175 = -4.42 = \acute{p}$ and from Table VII, $+169/175 = +0.965$ class intervals or $+0.00193$ in. so that $M_y = 0.0785 + 0.0019 = 0.0804$ in.

$$\sigma_y = \sqrt{\frac{3{,}916}{175} + (0.965)^2}$$

$= 4.83$ class intervals or 0.00966 in. $p = \acute{p} - (0.965 \times 0.325) = -4.42 - 0.31 = -4.73$. $r = \frac{-4.73}{4.83 \times 3.28} = -0.298$ while the

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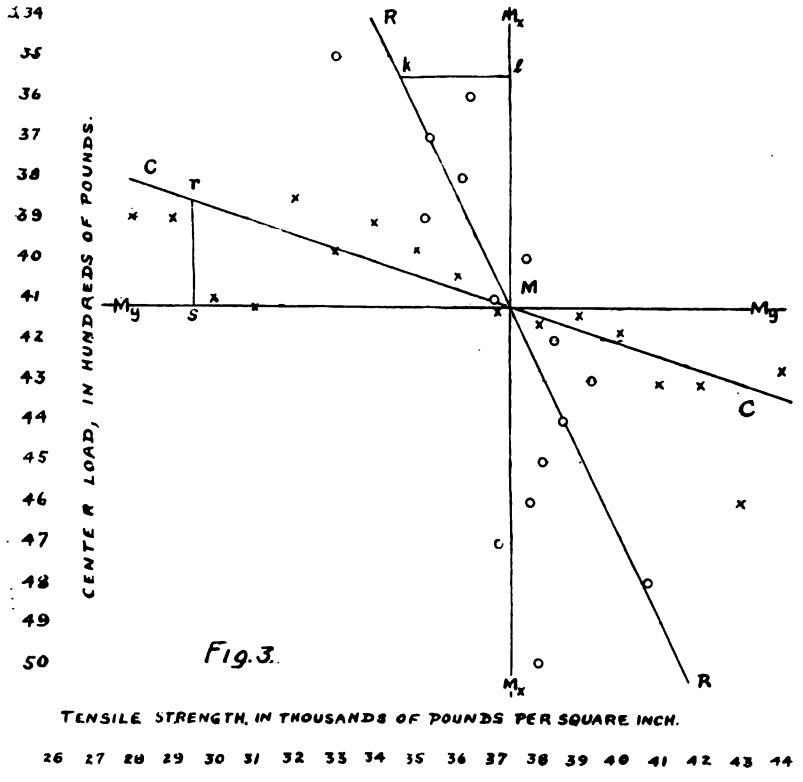

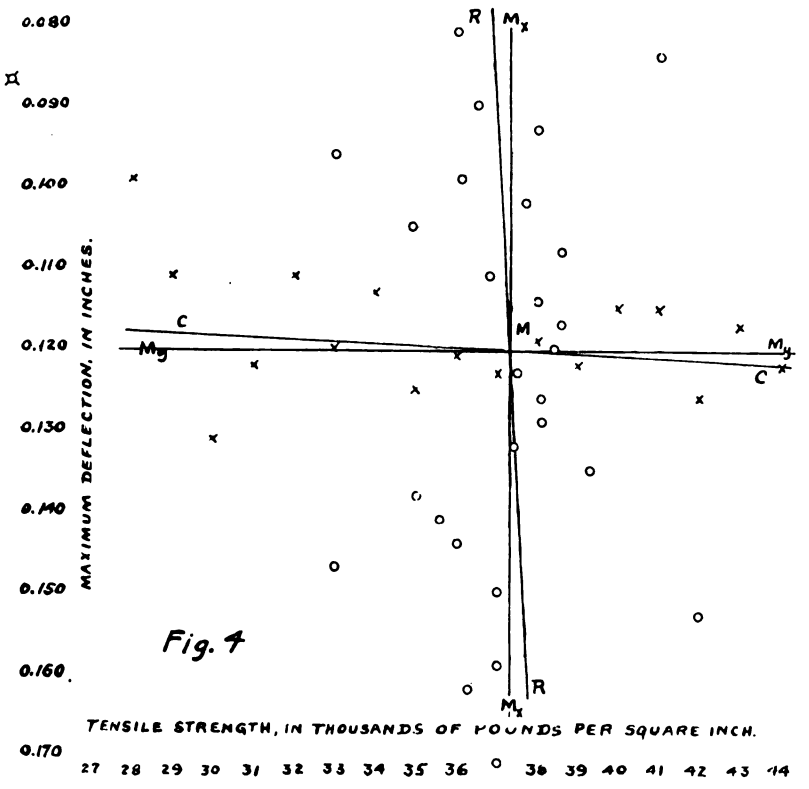

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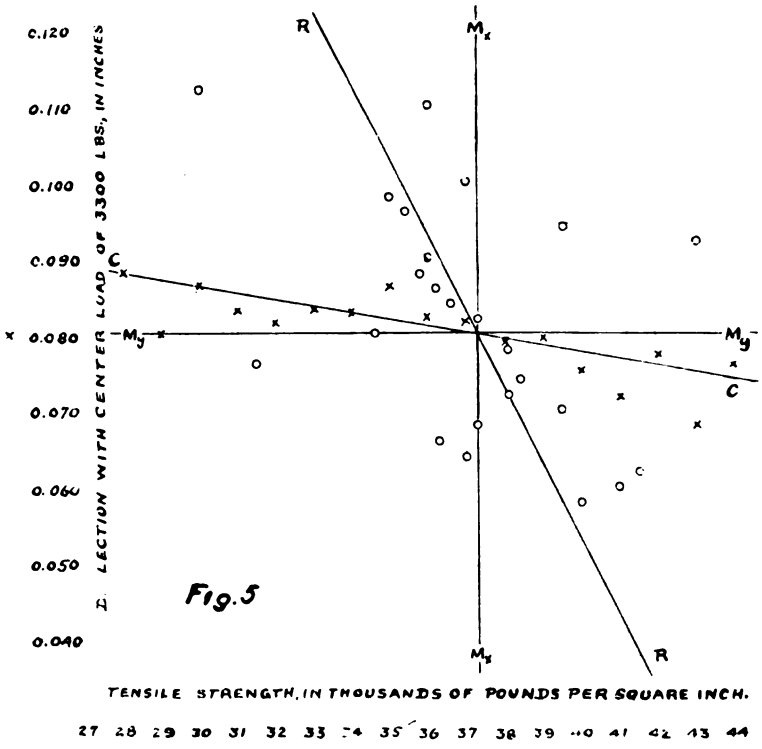

FIG. 5

probable error is 0.0464. Thus r is 6.41 times as large as the probable error and correlation is a certainty.

The equations for the lines of regression are

$X = 45{,}475 - 101{,}200\ Y$ for RR (14)

$Y = 0.1131 - 0.000000877\ X$ for CC (15)

Fig. 5 was drawn with the help of these equations. It will be noted that the scale for Y runs in the same direction as in Fig. 1 and 2, but that the lines of regression slope in the opposite direction. This difference is due to the negative sign of r. The scale of Y in Fig. 5 was inverted, as compared with the scales of Fig. 3 and 4, so that the lines of regression should slope in the same direction.

It is of interest to substitute in equations (14) and (15) the value of Y from equation (13), and in this way we obtain

$$X = 45{,}475 - \frac{101 \times 10^9}{E} \text{ for RR} \qquad (16)$$

$$1/E = \frac{11.37}{10^8} - \frac{8.82\ X}{10^{13}} \text{ for CC} \qquad (17)$$

Using equation (17) and taking values of X of 25,000 ; 37,325 and 44,000 lbs. per. sq. in., that is, the minimum, mean and maximum values of tensile strength in our 175 tests, we find that the probable values of E, at a load of 3300 lbs., or fibre stress of 5150 lbs. per sq. in., would be 10.9, 12.4 and 13.3 x 10^6 respectively. In German handbooks the value of E is usually given as 14,220,000 lbs. per sq. in. The common experience is that E decreases with an increase of load, and this value can only be regarded as a rough average, and equations (16) and (17) as applying only to a stress of 5150 lbs. per sq. in.

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FACULTY HONORS

IV

CHARLES M. SPOFFORD

Appointed as Advisory Engineer to the Directors of the Port of Boston

BUT a recent confirmation has come of an honor conferred on a member of the Institute faculty, which, while in itself wellworthy of note, marks but one in a list of similar appointments by which this man has lately been honored.

Professor Charles M. Spofford, Hayward Professor of Civil Engineering, of the Department of Civil and Sanitary Engineering, has been appointed as Advisory Engineer to the Directors of the Port of Boston. The significance of this appointment becomes evident when it is realized what strides Boston has made in the past few years in putting itself "on the map" as one of the first ports in the land, outstripping in its rapid progress cities of better geographical location, of easier access to important markets and with equally good transportation facilities. This has been due in great measure if not wholly to the modern and wide-awake policy of the Directors of the Port, and to those others whose efforts have brought about the great growth in the facilities and commerce of the harbor.

Naturally Professor Spofford has not as yet entered into any great engineering problem with relation to this office, but coming as it does on the heels of another appointment to an important position of service on a public commission, it emphasizes his standing as an engineer.

By this second appointment Professor Spofford was made a member of the Commission on Terminal Facilities of Boston. May 28, 1915, an act passed by the State Legislature of Massachusetts reads in part: "Resolved, that a commission be appointed to be called the Terminal Commission, which shall investigate the subject of Terminal facilities, and shall also consider the improvement of facilities for the transportation of freight in the metropolitan district. The Commission shall investigate the best method and the means for the development and the improvement of the facilities for the transportation of property in, to and from, and with relation to the City of Boston, the need and possibility of providing necessary interurban facilities for the transportation of freight, including the practicability and probable cost of constructing freight lines for the accommodation of steamships, railroads, warehouses, markets and manufacturing and industrial establishments; the desirability, feasibility and probable cost of promoting business opportunities within the metropolitan district by the establishment of industrial centers; and . . . ," etc.

To this commission, the tremendous possibilities of which can be grasped by a perusal of the act which brought it into being, ex-Governor Walsh appointed Professor Spofford as engineering expert. In fulfilment of his function as a member of the commission Professor Spofford has already visited the great industrial and railroad centres of Chicago, St. Louis, Kansas City, Baltimore, Philadelphia and New York, where he has studied the various methods of solution of this problem. In his work Professor Spofford has easy access to, and will probably take advantage of, a fine series of observations and tabula-

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tions made by Technology students and the Electrical Research Laboratory which has considered many phases of the transportation problems in its work on the efficiency of motor trucks.

This appointment followed close upon the completion of another task which Professor Spofford as an expert in the service of the public had undertaken. This was his work as a member of the Special Committee on Real Estate Assessments for the City of Cambridge, which committee was formed for the purpose of formulating a proper system of taxation for the city.

But the broad field of Professor Spofford's interests and service does not end here. For Professor Spofford's special sphere is that of Sanitary Engineering. And his work in this field might perhaps be best illustrated by his work for the City of Fall River, as a member of an outside engineering firm. Fall River, the third city of the State of Massachusetts, with a population of 128,000, and a center for the manufacture of cotton cloth, has for years permitted the growth of a nuisance which aside from impairing its value as an industrial center, threatened the health and welfare of the entire population. This was the use of the Quequechan River as both a general supply stream for the use of the condensers of the fifty odd mills on its banks, and as a dumping place for the exhausted hot water, refuse and sewage. The river becoming increasingly shallow with time was forming flats, which being exposed by the summer droughts form breeding places for disease. But the sanitary problem paled before the engineering question. The supply of water for the mills was becoming inadequate, both in quantity and quality, and though the North and South Ponds which feed the Quequechan have an abundant supply of water practically at hand, yet in the summer time a number of mills have been forced to close down because of lack of water in the ever shallower Quequechan. It was to solve this problem that the firm of Fay, Spofford and Thorndike were engaged as consulting engineers, and the result of their investigation has been the proposal of an immense water subway, containing three separate conduits, one for the supply of cold water to the mills, another to carry the surface drainage and sewage to tide water and a third to carry back the heated water from the mill condensers, after the oil impurities have been separated from it, to the surface of the feed reservoir, the South Pond. This immense conduit as planned involves a huge underground aqueduct consisting of a mile and a half of concrete construction the dimensions of which are practically the same as those of the new Cambridge tube.

It is interesting to note that in connection with the design of the oil separator for the condenser water another member of the Institute Faculty was called in consultation, Professor W. K. Lewis.

Professor Spofford graduated from the Institute in '93. Until 1903 he was connected with the Phoenix Bridge Co. From 1903 to 1905 he was an assistant professor at Tech, and from 1905 to 1909 he served as professor at the Brooklyn Polytech, and since 1909 he has been Hayward Professor of Civil Engineering. Since 1900 Professor Spofford has been identified with many important engineering works, with the design of numerous bridges, and with engineering investigations and reports. He is a member of the Am. Soc. of Civil Engineers, the Boston Soc. of Civil Engineers, of the National Association Cement Users, of the Society for the Promotion of Engineering Education,

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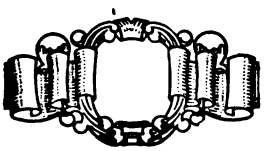
and a director of the Brooklyn Engineers Club. He is the author of "Notes on the Theory of Structures," "The Theory of Structures" and numerous papers on scientific and engineering subjects.



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WHY NOT PREPARE?

By ALLEN ABRAMS, M. I. T., '15

General Manager of the M. I. T Combined Musical Clubs, 1914-1915

Editor's Note. Mr. Belcher's article in the February, 1916, issue of The Technology Monthly giving his views of the futility of preparedness, has aroused a most emphatic storm of protest. Mr. Abrams' view, together with Mr. Goldsmith's article, which follows this one, are the most complete refutations that we have heard

IN the February issue of the Technology Monthly there appeared an article by Mr. Belcher wherein he purported to prove that national preparedness was both illogical and impossible. With fascinating phraseology and inimitable irony, he has composed a production to read which is a genuine treat. But unfortunately in the presentation of such an issue, the fundamental reasoning to support good phrases must be just as firm and well-grounded as the foundation of a Krupp 42 centimeter gun, or any other diabolical machine.

It is my intention to consider briefly the arguments Mr. Belcher has advanced (representing as he does a considerable constituency in this country) and to take issue with him in certain respects. However, let it first be thoroughly understood that Mr. Belcher and I fully agree that war is productive of human suffering, is of no real economic advantage and is a breeder of race hatred. As a logical consequence we believe that world peace is wholly desirable—but we differ markedly as to the proper methods for consummating peace. With these facts in mind, let it be clearly understood that I shall be urging preparedness—not *for* war but *against* war.

The topical arrangement of this article as well as the quotations cited, (except where otherwise noted) are suggested by Mr. Belcher's previous article.

"IN TIMES OF PEACE PREPARE FOR WAR"

Under this caption we are told that war is the ultimate result of building battleships, casting cannon, and mobilizing men. In opposition to this statement let me quote Prof. Hart of Harvard, from an article in the World's Work—"The strongest and determining reason for war is the growth of race antipathies."

It is further claimed by Mr. Belcher that Germany prepared *for* war as no other nation has ever prepared, and that, whether her millions *wanted* it or not, they *got* war. Of course, we can have no patience with this argument when applied to America. In the first place, he would be foolish who would advocate an emulation of Germany's extreme measures in preparing *for* war. Moreover, I firmly believe that our democratic form of government, our patient and long-suffering attitude, as evinced in the distressing incidents of the European and Mexican situations, our cosmopolitan population, our non-militaristic traditions—all these, I say, relegate to the realm of the visionary any likelihood that we shall imitate Germany's example. Imagine, if you can, our officials toasting "The Day"—our President uttering "Ich und Gott!"

It would be futile to split hairs over

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opinions, or to argue the time-old controversy over the priority of the hen or the egg. Some will claim that preparedness induces war and others are equally certain that war induces preparedness. Be that as it may, Mr. Belcher quotes W. G. Sumner of Yale to the effect that "There is no such thing nowadays as a state of readiness for war"—a statement which I can scarcely reconcile with Mr. Belcher's previous conclusion that the present war was caused by preparedness. And if we further assume with Mr. Belcher that France and Russia were not ready for war, how shall we maintain that the World War was the result of preparedness? Are we to understand that preparedness is a one-sided issue?

Perhaps no one has summed up the whole situation more aptly than George Washington—"If we desire to avoid insult we must be able to repel it; if we desire to secure peace, one of the most powerful instruments of our rising prosperity, it must be known that we are at all times ready for war."

"I shall not arm to kill or maim Fritz, Ivan, Pierre, Giovanni because some one has deluded me into thinking I am his foe."

The broad bonds of brotherhood are here invoked as a sufficient reason why we should not shed blood. It is an ideal picture which has been drawn for us. Unquestionably I *am* fond of Fritz, Ivan, Pierre, and Giovanni; certainly I have no desire to shed their blood. And yet I carry a weapon. Fritz *might* try to sandbag me, Ivan *might* want to wring my neck, Pierre *might* like to put a bullet in my head, while Giovanni *might* explore for my heart with a stiletto —*just because some malicious fomenter of race hatred has deluded him into thinking that I am his foe.* You will agree that my suspicion is justifiable if human nature is to be the same in 1916 as it has been in 1915. In more popular parlance, *I don't want "peace at any price."*

CAN WE PREPARE?

We are told that we cannot prepare effectively. I believe that we can.

On the one hand, we must reject the extreme proposals of those alarmists who would begin at once to turn our nation into an armed camp; on the other hand, we must likewise reject the views of those pacifists who would have us sit by twiddling our thumbs, protected the while only by the long-suffering, Ford-fostered, storm-buffeted dove of Peace. There must be—there is—a reasonable middle course which we can pursue. Perhaps it will be by the adoption of the Swedish system of military training; by the establishment of summer military camps; by the construction of an adequate fleet of battleships; by the creation of a citizen army; or by a similar method suggested in a previous article by Mr. Belcher himself—"We must have a trained civil force, *free from all traces of military tradition*, of the nature of a political force, amenable to rational civil control." (The italics are mine.) I accept this—not omitting the joker. I care not how it be accomplished; all that I demand is adequate protection, and that right early.

Diverting temporarily from the subject, Mr. Belcher says, "Christ preached absolute non-resistance. The Bible affords the only reliable evidence upon this question."

I have no desire to engage in a controversy over Biblical interpretation and yet I must disagree with this statement. Because of the heightened effect, Christ frequently spoke in hyper-

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boles. As examples, let me quote two passages which will, at the same time, present the two extremes of Christ's teaching on resistance. "If any man smite thee on thy right cheek, turn to him the other also," and again, "Think not that I am come to send peace on earth; I came not to send peace but a sword."

Parallel with these sayings of Christ we have two incidents in His life: the one in which our Savior stood silent and non-resistant before Pilate and His accusers; the other in which He wrathfully drove the money changers from the temple.

How shall we reconcile these extremes in Christ's attitude? I believe that the most widely accepted, and the most reasonable interpretation is as follows: Resistance is no virtue when practised for personal, material advancement, or for purely selfish ends. On the other hand, when moral suasion has been exhausted, non-resistance is cowardly when it permits the abuse of those institutions and ideals which we hold sacred.

Finally Mr. Belcher says, "Fear not. Preparedness costs too much; we are too busy making money."

In view of what he has already said, I regard this statement merely as a euphonious lampoon. But because of the fact that this argument is continually directed against preparedness let us look into it a little further.

Some people have thought that fitting preparedness for defense would involve us hopelessly in taxation. Without laying claim to any extensive knowledge of taxation, I believe that they are mistaken. At the time of this writing no definite scheme has been settled upon, but the Administration appears to be favoring plans whereby the bulk of this preparedness revenue will be secured from the incomes of the rich. Perhaps this will be changed; some less equitable method may be employed. But even if the burden of this tax should eventually fall heavily upon your own shoulders (and many will argue that it *must*), I ask you, "Would you prefer an added taxation now or an impossible burden in a country devastated and ravaged as Belgium or Servia?"

And now that we have considered some of the arguments touching upon preparedness, you may be inclined to ask, "What matters it to me, whether America is ready to meet a foe or not? What material difference does it make whether I live in America run by Americans, or in an America run by English, German, Japanese or what not?"

As Thackeray has well said that "without sentiment there would be no flavor in life at all," it behooves us all to indulge occasionaly. Permit me then, to draw you a picture, rather crudely perhaps but I hope none the less accurately and vividly.

For the sake of our illustration, let us assume that I am a married man with a devoted wife and several children; and without much further stretch of imagination let us assume that I love my family and my home.

Unavoidable circumstances (the location of business interests, if you like) require that my family and I live in a community wherein we feel none too secure. Superficially the people are pleasant and agreeable; nevertheless I am suspicious, and particularly so of my two adjoining neighbors. Apparently these two are the personification of affability, and yet they hold too many mysterious conversations in subdued tones to suit me. I am a peace-

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loving citizen, but finally the fear of what they may be plotting against me and my family drives me to the hardware store. I purchase an automatic Colt pistol and, from then on, I carry it with me. There is no display to this preparation and yet I feel vastly more secure.

One still, dark night, I waken from my sleep, unaccountably nervous. There is subdued conversation outside, and on slipping to the open window I recognize the voices of my two neighbors. They are planning to enter my house, and I gather that they are not purposelessly armed. Presently, after a few muffled preliminaries, they jimmy a window (save the mark!—with my own garden trowel!) they enter stealthily in the dead of night. I challenge them:

"Halt, or I fire!"

They jeer, and in reply, they rush upon me. The trusty Colt responds to my touch, and in a trice, my two affable neighbors lie dead at my feet.

Now, you may regard me as an unreasonable sort of fellow and yet it would be hard to convince me that I had done wrong in buying that pistol and in using it to protect my home. I have been keen on pistols ever since.

Finally, let me add, that unless preparedness be advocated by an inborn love of country, it is a snare and a delusion. Therefore when a man confronts us with the statement that "I regard patriotism as a cardinal vice," we are forced to admit that either he has indulged in a clever bit of pasquinadery, or that he lacks the fundamental reason for advocating preparedness. My only reply to his confession is this: It is just as natural for men to unite in nations under a flag as it is for them to form clubs, labor unions or kindred organizations. I have no sympathy for the spasmodic, jingoistic patriot who yells bloody murder while he gropes industriously in the pork barrel for a plump side of bacon. And yet there are millions of sincere, peaceful, home-loving men and women in this country who glory in the history of America—their country; who are proud of their American forebears; and who thrill—yes *thrill*—at the sight of the American flag. Some may call them simpering sentimentalists, but I call them true patriots. They abhor war but they are sincere in declaring that they will go to war when it becomes *necessary* for the preservation of the national integrity. Personally, I want to join their ranks. All too vividly there dwells in my memory the self-inflicted fate of "The Man Without a Country"—overdrawn though the story be. I thank God for America and that I am an American.

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WHY PREPARE?

By HENRY F. GOLDSMITH. M. I. T., '17

THE "nation of shopkeepers" it was which finally brought to his knees the great Phrasemaker. The trouble is that you cannot include a whole nation or even one man in a single all embracing magic word or phrase. Who would dare designate the glorious Socialist fraternity as a party of Phrasemakers? And yet careful perusal of an article from the pen of a professed Socialist exposes it not as an article against preparedness but a collection of phrases, hanging on to each other by the over fragile threads of Socialist logic, and presenting a most confusing array of inconsequent points. A request for an answer was made. Yet what has the philosophy of Kant or Tolstoi to do with preparedness? Why drag in Leo Frank, Anthony Comstock, Fritz, Ivan, Pierre, and Giovanni into the question of Preparedness? And why, I repeat, why include the overharassed Mayor in the discussion? Why not present one single cogent argument and carry it through? Then we poor vexed common people could find something tangible at which to take a fling.

We are told preparing for war would not prevent it. We are not assured that unpreparedness would prevent it either. Even the Socialists do not insist that were our shores ravaged, our towns invaded, our children murdered, our women outraged, and all the horrors which the socialist delights in painting as morbidly as the next man, even they do not insist that they would turn the other cheek. The question is not whether we want war or whether we want peace—for no matter what we want we may have something else forced upon us—to which even a Socialist might well assent. The question is, are we to act as men, men of red blood, men who will fight for an ideal, even though it be a mistaken one, or as weak cowardly creatures who would submit under the scourge of any arrogance rather than provoke the spilling of blood. The trouble with the Pacifists is not their heads—their reason functions correctly enough—but with their spirit. They fail to remember that life after all is a finite thing, that the price must be paid at one time or another, and they cling obstinately to the idea that life under any conditions is preferable to death on the field of battle with a great idea as the battle cry, and the most powerful of the emotions of man as the driving force - patriotism, the struggle for the home and fatherland, for wife and child Is life of itself so wonderful a thing that it is better to live in shame than die in honor? Are we become so sordid that we prefer to crawl a miserable existence on this little planet rather than feel once in our lives the inspiration of a great emotion?

Who is not moved by the cry of one such as Bozarus: "Fight for your altars and your fires, fight for the green graves of your Sires, God and your Native Land!" Who, but a Socialist?

Are we in truth "too proud to fight?" Or are we again phrasemaking? If we are really too proud to fight, and remember that is a wonderful thing even to conceive of, we are either saints or possessed of godhead, and I greatly fear that as a nation we fall short of the

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requirements. Granting of course that the individual Socialist qualifies.

What though is the trouble with our Socialists? Tell me not they have degraded to the harmless inanity of the anarchist! Where is all that entertaining blood and thunder they used to parade for our shuddering delight? O Tempora! O Mores! What! Is there to be no industrial upheaval, no revolt against the Iron Heel, no alignment in fierce battle of the down trodden proletariat against the arrogant plutocracy of wealth? Ye Shades of Marx! Have they forgotten Lasalle, have they forgotten the glories of forty-eight, the blood-stained barricades, and the gloriously defiant red flag? Wake unto your past, Socialists! There were men among you then, men who were not too proud to fight, men who even preferred to champion a lost cause to the death rather than desert to the flag of compromise.

The truth of the matter is that all of us, stunned by the present debacle look with sickening apprehension at the terrible blood waste, the frightfulness of it all, and we forget that there is a greater price even than frightfulness by which a nation can buy its existence. The world drones along in its commonplace way until the prophets shout: there are no more virtues, we are all base materialists. Then the crisis comes. And the world arouses itself, and dons its ancient armor of idealism. There is much blood and infinite suffering. And the prophet straightway turns about and rails: "Ye bloodthirsty beasts! Will ye never cease in your murders in the name of country, in your outrages in the name of God?" But the prophet is a false one. And the world heeds him not, but persists in its blind idealism.

That the clash of the great passions of the universe is terrible in its results cannot be denied. But to preach nonresistance, which is the corollary by the way of unpreparedness, is to preach nihilism, pure and simple. Followed out to a logical conclusion it would bring us all to the condition of the Buddhist. Nirvana as the highest good —Nothingness as all desirable.

I venture to say that not a man who has the average amount of red blood in him, and the average love for fair play, will gainsay this. There is not a man who when put to the test will not fight for his notions of righteousness, deprecating as he may warfare and bloodshed. Even our Socialists, milk and watery as they seem to be—Henry George and his Single-taxers become first page thrillers aside of them—can now and then be goaded into self protection.

The question then becomes not whether we will fight when the time comes, for we all know that we shall whether we like it or not—and most of us really like to fight, it is the best gambling proposition we know—but whether preparedness will hasten that fight or retard it, whether preparedness will give us a fairer chance of coming out victorious. For much as we individually may like to scrap, we have no desire to plunge our country and our dear ones into ruin.

But we have seen that when it comes to a question of righteous anger that unpreparedness has never protected us. Witness the Spanish War. Also the Civil War, also the Boers fighting for their independence, and a score of other instances.

Granting also Mr. Belcher's contention that the present war is in fact a sordid commercial struggle, and extending that to the assertion that most wars are sordid commercial affairs and have

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their roots in economic conditions, still we see that unpreparedness is again no guarantee. Our own Revolutionary War was a commercial war, a war for commercial independence, little else, yet despite the sordidness of the cause, the results have been in most every respect salutary. Again our Civil War was fought for economic reasons rather than ethical. And again the results have not been such, however terrible the struggle and devastation may have been, that they should be decried.

And in neither of these cases any more than in the present case of Belgium did unpreparedness act as a guarantor of peace. The Revolution found us pitifully weak, unorganized as a people, without credit and without arms. Again in 1812 we were unprepared, and in no position to invite combat. Rarely had such a disgrace been recorded against any country—its capital city surrendered to the enemy without a struggle, without a shot fired in its defense. Once more the Civil War caught the North napping, and as a result both sides had to pay the fearful price of four years devastating combat. And in '98 the fact that we emerged triumphant was due not to our own preparedness—it was practically non-existent—but to the more flagrant neglect of the enemy. And yet in every case we looked not to our preparedness when we entered upon a war we looked instead to our principles, to our ideals. Indeed so much seems evident: that whether we enter a war or not will not be decided by the number of machine guns in our arsenals or the number of armed men in our mobilization statistics. Were there not a single soldier to rally to the standard we should become embroiled as easily as if every man were trained to the minute and we were prepared to the "last button on the gaiter of the last soldier." Of this history offers full and sufficient proof.

Some worthy people have even made an argument of this. What if we are not prepared, they query. We never have been before, and yet we have always had a happy finale to our ventures. We shall always blunder through somehow. Such an argument needs no answer, but if one were sought, the present example of England would be sufficient, England which was prepared in a thousand ways of which we have no conception, England with a standing army and equipment to make our military establishment ridiculous by comparison, England with a navy prepared to the last detail, with absolute command of the seas, England has had to pay and will yet pay many times over for the purblind policy of her rulers. Or if further evidence is needed let those persons consult the statistics on the walls of the National Defense League Rooms, hardly fifty paces from Tech, and compare the terrible cost in blood and treasure as between a trained and an untrained man in times of war. Or let them read of our last victory, the Spanish-American War, and compare the handful of men killed by enemy bullets to the army which died, as the victims of American slovenliness, American lack of organization, American failure in providing the essentials of war and American graft.

Mr. Belcher mentions the "fruitful and interesting subject of non-resistance." To me it likewise appeals as interesting and fruitful. But from a different angle. The trouble with many Americans is that they live too much by "dope." They figure things out and said things must necessarily transpire as they have figured. For example, the Ford Peace Party. That had all been "doped out" in advance by one of

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the cleverest brains in America. "Out of the trenches by Christmas!" It was grand! It was thrilling, exciting, spectacular, and withal, in dead earnest. Based on an absolute misconception of conditions, on blank ignorance of the facts, on a total lack of appreciation of the possibilities, the expedition was of necessity a farce. It had but one result —to make America the laughing stock of the nations. And yet it had been all doped out beforehand. Likewise with the policy of non-resistance. Many of us think we are beloved as a nation. Our foreign policy has always been most liberal and honest. We have never stooped to underhand methods of diplomacy, we have championed the downtrodden, we have ever been averse to conquest, we are generous, we have succored whole nations in distress, we are neighborly. Therefore, we are, we must be beloved.

Once again, pure "dope." What are the facts? We are ridiculed by most all peoples, we are hissed at in English music halls, we are detested in Germany worse than the German's avowed enemies, we are tolerated in France, cordially disliked in Russia, and in Japan there burns for us a hatred truly oriental in depth.

Furthermore, we are envied. We have tremendous wealth, we have uncounted resources, we live in a fair country. These things are coveted by nations as well as by men. "Licking us would be like taking candy from a kid." And we shall surely lose our candy unless we take means toward defense.

So that the real question becomes, not "Why Prepare!" but HOW PREPARE? For I think, Mr. Belcher's objection to the contrary notwithstanding, most of us still fondly cling to the idea that there is good common sense in the phrase: "IN TIMES OF PEACE PREPARE FOR WAR."

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THE TECH METHOD OF TEACHING

THE OPINION OF RECENT GRADUATES

EDITOR'S NOTE

IN speaking to the editor rather informally upon the subject of successful technical education, a recent graduate of the Institute mentioned the fact that a Tech man is expected to have more general information upon technical subjects, and actually has less, than the majority of his contemporaries. The argument put forth is, in general, something of this sort:

"Coming fresh from preparatory school as most Tech freshmen do, the student is rushed into the intricacies of the so-called liberal education for which he has come so far. He is led through a maize of mathematics, general subjects and sciences. He is taught to regard everything in the light of technical research. He is imbued with a certain amount of Tech Spirit usually based upon a false foundation. He is taught to forget all that is human, to make himself a machine for reproducing in like kind the thoughts of his professors. He is taught incidentally that Tech is great—so great in fact, that it overshadows everything else on earth. And the 'Tech method' is unfolded to him with all its perplexities and uselessness.

"He is given the renowned Problem method. He is taught the easiest subjects the hardest way. He is taught to think in one way—a way which is useful only in special cases. But for the general problems which he finds later that he must encounter, he is given no preparation, no defenses, no method of attack.

"It is strikingly characteristic of the Tech man that he tackles his problems the hardest way. He is taught that all problems are difficult and that they can be approached in only one way; with the result that he becomes a monomaniac—with a desire to reduce everything to terms of ions, entropy and a ten-inch slide rule.

"It may be well to train the youth in the ways of the great Technology thinkers—but so many times—in such a majority of cases is the Tech man's morals disturbed and his health injured, sometimes permanently, that a great many of the more active thinkers of the recent graduates declared that they will 'never send their boys to Tech.'

"Repeatedly Tech graduates have told me that their health was so impaired by the Institute Training that they were not themselves for years after graduation; their morals were so upset and their views of life so distorted that it is only with the greatest effort that they have become normal again. I remember one graduate telling me that the trouble with the members of the Tech instructing staff is that they themselves learned all they know at the Institute, and the

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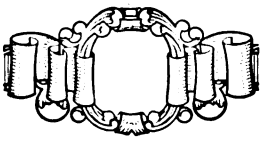
sum-total of knowledge and common-sense in the Institute is growing less every year in consequence thereof."

Surely the indictment of Tech cited in the opinions of the alumnus whose ideas are expressed above is not a true diagnosis, but there is so much truth in the thoughts that we have taken the opportunity of presenting them to our readers.



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All manuscripts submitted for publication in the TECHNOLOGY MONTHLY AND HARVARD ENGINEERING JOURNAL should be accompanied by the writer's full name and address. Manuscripts not accepted for publication will be returned only if the author so requests. Photographs, drawings, etc., will be returned to the contributor immediately after publication.

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EDITORIAL

ENGINEERING LITERATURE

WATCH the students in the libraries and reading rooms. Do they read magazines of engineering or science? No, they merely look them through and read a very few articles. If the man is a chemist and *does* pick up an engineering journal he will perhaps read the articles on chemistry, but those articles relating to general engineering, perhaps of the greatest importance, are entirely neglected.

Unfortunately, the big majority of students are not interested in subjects in which they are not specializing. They do not develop the habit of reading on a variety of subjects.

This habit of *looking over* engineering magazines follows the student in his after life. There has been considerable uncomplimentary criticism of Tech because our graduates too frequently know very little outside of what they actually studied at the Institute.

WHAT YOUR EMPLOYER DEMANDS

JUST what is your employer going to demand of you when you "get out?" What qualities are going to count, what abilities will bring advancement, what special training will enable you to score? The sensation of the recent meeting of the American Society of Civil Engineers, was the answer to these questions as compiled from the qualifications demanded by engineers the country over.

Do you know that the scientific training you are receiving at Tech counts least in your getting and holding a job?

Do you know that things which are *not* taught in the classrooms rank higher than proficiency in studies in the viewpoint of your employer?

Do you know that of the qualities which will bring you favor in the eyes of the "Boss," 87 per cent are charged up to character, and 13 per cent, only 13 per cent out of the total of 100, is accorded to technical training?

These are the actual figures presented by the committee report. Questions were sent to civil engineers throughout the land, asking what each individual thought essential in the young men he considered for employment as his assistants. From the maze of answers returned, the qualities which stood out dominantly as in universal demand, were qualities referring in the vast majority to character. Integrity, loyalty, leadership, these are the things your employer demands.

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Your honesty counts more than your mathematics. Your loyalty counts more than your laboratory skill. Your qualities as a leader when placed in the balance of your value to your employer far outweigh all the proficiency you may gain in your profession by your four years labor at Tech.

Where are you going to learn these things? Are they taught here? Are they taught in any college? Can they be taught? If you do not learn them who is to blame? Here they are—87 per cent they count, 87 per cent toward your success in life. You have come to Tech in order to become a successful engineer, and yet your classroom training contributes but little more than one-tenth toward enabling you to meet the demands of the market. Did you have that in view when you came here? Or did you consider as most of us, that a Technology training would count nine-tenths, and the other things one-tenth?

This is important, it affects your whole future. You may be lacking in some of that 87 per cent, that nine-tenths of which you have not heard. Are you at fault, or is it the national educational system? Think it over.

OUR NEW CO-OPERATIVE SOCIETY

IN connection with the report of the Harvard Co-operative Society in the Boston Herald a short time ago, it is to be remembered that an agreement with the Harvard Co-operative Society and Technology was effected some time ago. The January, 1915, issue of The Technology Monthly and Harvard Engineering Journal gave the complete text of the agreement, the report of the committee and an editorial comment worthy of note.

The Harvard Co-operative Society did $15,000 more business during the last six months than during the same period one year ago. The total sales for the period July 1, to December 31, 1915, were $230,111.30 as compared with $214,963.88 for the same period in 1914. There was an increase of 50 per cent in the furniture department. The Technology branch of the Harvard "Co-op" will be opened this fall. The business with graduates has been steadily growing, and this feature of the store will be especially looked after in the future.

The affiliation of the Technology with the Harvard "Co-op" is of great importance to Technology, and is in the nature of a true reorganization rather than a renovation. Criticisms of the present Technology Society are in the nature of objections to the high prices charged rather than to the service rendered, on the one hand; and against the centralization of management on the other. The Society should try to sell at moderate prices such items of necessity as books and stationery. With the students and alumni acting together this branch should be made a true Technology Institution.

The lowering of expenses of the average student should be the sole aim of our new "Co-op." At Harvard this has been accomplished, as well as at such colleges as Princeton, Yale, etc. There is no reason why it cannot be more effectively done under the new organization than has been true in the past. The above report of the Harvard "Co-op" should indicate what the future ought to bring forth.

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HARVARD GRADUATE NOTES

'96—Winslow H. Herschel, assistant physicist in the U. S. Bureau of Standards, at Washington, D. C., has recently published two articles on "The Most Economical Vacuum for Steam Turbines" and "Determining the Equation of a Curve."

'00—A. S. Hawks is with the Busch-Sulzer Bros. Diesel Engine Co., 2nd and Utah Streets, St. Louis, Mo.

'11—J. F. Gowen is with Smith, Hausen & MacIsaac, Inc., 18 East 41st Street, New York City.

'14—T. E. Kendall has accepted the position as limnologist and chemist for the U. S. Government in the Canal Zone. His address is Gatun, Panama.

'14—C. B. Abbot is employed by the T. J. Pardy Co. in the construction of a reinforced concrete factory for the American Graphaphone Co., of Bridgeport, Conn.

'15—S. T. Barker is employed with the U. S. Coast and Geodetic Survey at Washington, D. C.

'15—A. C. Hawkes is employed in Bridgeport, Conn. His address is 678 Warren Street.

HARVARD ENGINEERING SOCIETY OF NEW YORK

The ninth annual dinner of the Harvard Engineering Society of New York was held Saturday evening, December 11, 1916, at the Harvard Club in that city. One hundred thirty-eight members and guests were present. Clifford Richardson, '77, president of the society, was toastmaster. The other speakers were Hon. Frederic A. Delano, '85, vice-governor, Federal Reserve Board; Prof. Charles R. Mann, Carnegie Foundation for the Advancement of Teaching; Ira N. Hollis, president, Worcester Polytechnic Institute; Prof. C. A. Adams of Harvard, Ralph S. Foss, '03, and John C. Montgomery.

Mr. Delano reviewed the work of the Federal Reserve Board since its creation, and outlined some of the tasks yet to be undertaken. Professor Mann gave a brief digest of opinions already obtained from practising engineers as to the relative importance of various attributes for success in the profession, and as to the extent to which the educational institutions are cultivating those attributes. Professor Hollis told of industrial conditions and the strike at Worcester. Professor Adams spoke of the workings of the agreement with the Massachusetts Institute of Technology. Mr. Foss and Mr. Montgomery spoke in a ligher vein.

Professor George F. Swain of Harvard, and General Leonard Wood, U. S. A., whose names were on the program, were unable to be present. General Wood was expected late in the evening, but when at 11.15 it became apparent that he would not arrive, the gathering broke up with the singing of "Fair Harvard."

Besides the speakers mentioned there were present, Prof. H. J. Hughes, '94; Robert Ridgway, honorary member; R. T. Dana, secretary, Yale Engineering

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Association; C. H. Higgins, secretary, Princeton Engineering Association; Captain T. M. Robins, U. S. A.; and the following members of the society, with their guests: H. J. Alexander, '00; H. W. Andrews, '05; H. W. Bender, '08; W. E. Belcher, '04; J. L. Binda, '10; W. F. Booth, '84; W. C. Brinton, '07; J. E. Bunting, '98; C. E. Chase, '07; H. D. Cheever, '88; W. N. Clark, '03; A. F. Conant, '07; F. W. Daggett, '99; F. H. Davol, '03; C. R. Dean, '82; W. Delano, '74; T. C. Desmon, '08; G. E. Doyen, '08; D. G. Edwards, '03; K. B. Emerson, '02; J. H. Federal, '93; A. D. Flinn, '00; A. H. Fox, '03; H. H. Fox, '00; C. P. Frey, '85; Charles Gilman, '04; F. N. Goble, '02; H. Goldmark, '78; J. F. Gowen, '11; H. M. Hale, '04; W. L. Hanavan, '03; H. L. Harrington, '98; J. R. Healey, '97; W. S. Higgins, '12; J. P. Hogan, '03; C. M. Holland, '06; S. U. Hopkins, '97; H. P. Henderson, '01; E. N. Hutchins, '08; A. C. Jackson, '88; J. W. Knoblaugh, '97; A. L. Kimball, Jr., '12; J. M. Levine, '06; J. P. Locke, '00; W. Low, '05; F. Lyman, '74; D. B. McAllister, '05; L. P. Marvin, '98; F. Mason, '96; T. Maynz, '10; W. Meadowcroft, '01; E. Q. Moses, '02; F. M. Newton, '98; G. Newell, '98; W. S. Nichols, '99; W. H. Nye, '02; J. C. R. Palmer, '04; C. P. Perin, '83; J. P. H. Perry, '03; N. B. Pope, '02; A. S. Proudfoot, '02; George S. Rice, '70; E. L. Robinson, '14; G. H. Roosevelt, '13; J. A. Roosevelt, '07; R. R. Rumery, '96; M. H. Ryan, '99; J. F. Sanborn, '99; E. B. Smith, '08; E. N. Smith, '04; C. W. Stark, '03; J. V. Stark, '07; W. F. Steveson, '97; R. K. Tomlin, Jr., '07; D. L. Turner; A. Tyng, '04; W. B. Updegraff, '02; A. L. D. Warner, '03; T. H. Whitney, '00; E. B. Whittlesey, '05; F. Wilcock, '00; N. R. Willard, '00, and J. L. White, '06.

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LOCAL COLOR

JANUARY

Our hockey team has won a game,
  It took two years to do it.
The Glee Club manufactures noise,
  There's simply nothing to it.
The Juniors had a feed one night,
  Which really was a winner.
    McRae's all right,
    He's gone to fight,
  The 'lumni had a dinner.

Don Belcher wrote an article
  To start the fellows talking.
The Profs made up some stiff exams
  And had the Freshies balking.
The Chess Club lost a game or two,
  Which is to be expected.
    Chin Chin's the show
    Where all should go;
  And where is Heat? Neglected!

The orchestra is tuning up
  And bursting out in pieces;
The Senior now is starting in
  To work upon his thesis.
Technique is on the jump this month,
  DeBell is quite a worker.
    The big Tech Show
    Is on the go,
  And no one likes a shirker.

But Juniors have been working hard
  And earned their long vacation.
The Music Clubs have planned a trip
  To cover this big nation.
The Sophmores killed the physics test
  By cramming at the finish.
    A half year 'long,
    We're all in wrong;
  Our numbers now deminish.

Carl J. Heath, '17.

WE THINK SO TOO

"Charles, you're spending too much money this year. Too many dances, too many clothes, too many taxis, too many—"

"Well, father, I'll tell you how I look at it. It seems to me that every family ought to be able to support *one* gentleman."—Cornell Widow.

FOR ALL TO USE

Architect—Now, don't you think it would be well to have a pergola attached to the west side of the house?

Newlyrich—On the west side of the house? I guess not. I want that pergola right in the parlor, and I don't want it attached to nothin'. Put it on wheels so the servant can slide it out of the way when the guests are through playin' on it and want to tango.—Punch.

HOW DID HE MEAN?

Skanum—What do you say to a little chicken, old top?

Kanum—Don't ask such personal questions.—Chaparral.

THEN WHAT BECAME OF THE HAIR?

Sentimental Sue—"Do eyes change color?"

Rollicking Rollo:—"They say blue eyes become brown hair."—Cornell Widow.

"Say, was Nero that gink that was all the time getting frozen to death?"

"Naw—that was Zero—a different gink altogether."—Mo. Outlook.

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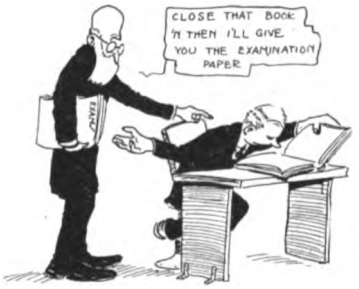
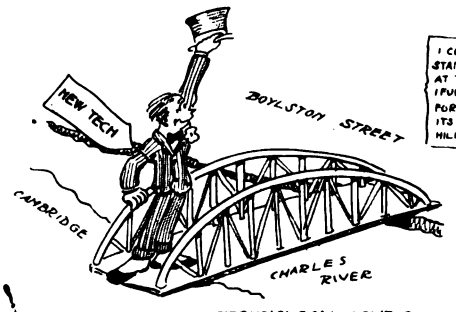
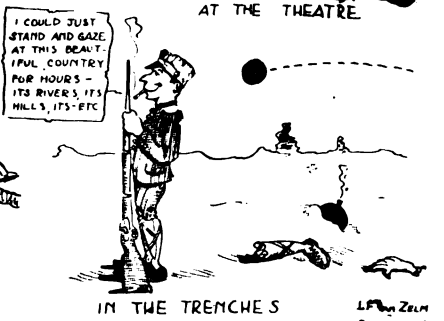


JUST BEFORE EXAMS

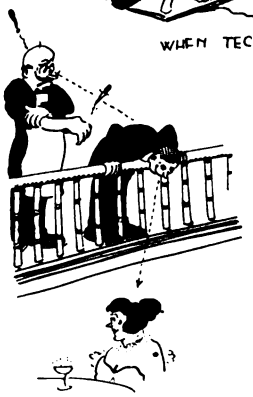
AT THE THEATRE



WHEN TECHNOLOGY MOVES

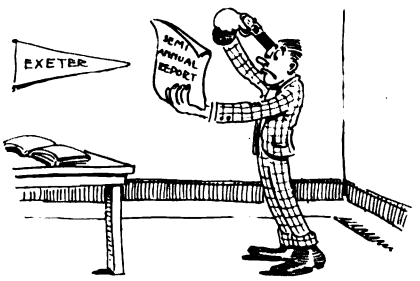


IN THE TRENCHES

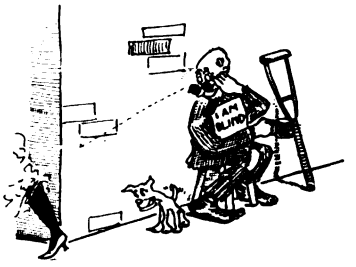


AT THE RESTAURANT

WHEN ITS TIME TO RETIRE



WHEN REPORTS CAME OUT



WHEN A MAN CAN'T RESIST IT.

ENTITLED — "ONE LAST LOOK"

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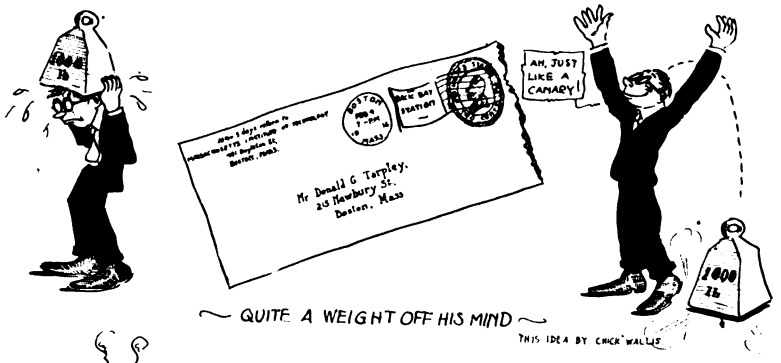
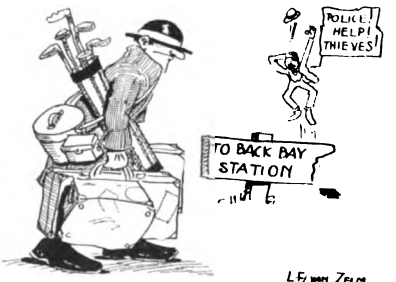


~ QUITE A WEIGHT OFF HIS MIND ~

THIS IDEA BY CHICK WALLER

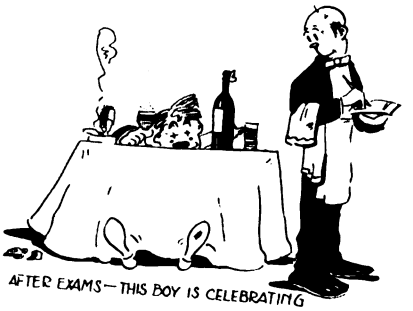
AINT IT THE TRUTH THO — THEY NEVER ASK HOW MANY Cs YOU GOT



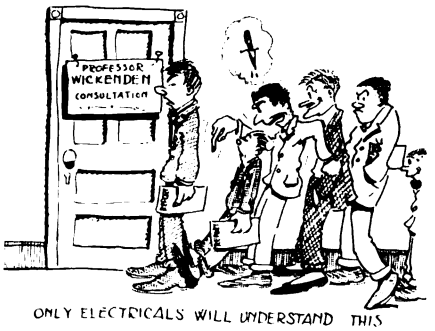
AFTER A SESSION WITH THE DEAN.

L.F. VAN ZELM ~ 1918

AFTER EXAMS — THIS BOY IS DROWNING HIS SORROW



AFTER EXAMS — THIS BOY IS CELEBRATING



ONLY ELECTRICALS WILL UNDERSTAND THIS

BUT THIS WENT STILL ON-EVEN THRU EXAM WEEK

"RELATING TO EXAMS — 'NOUGH SAID"

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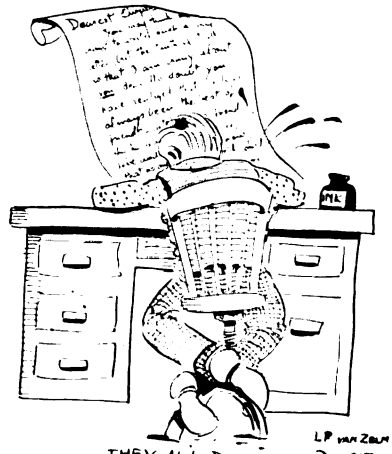
TOO BAD HENRY!

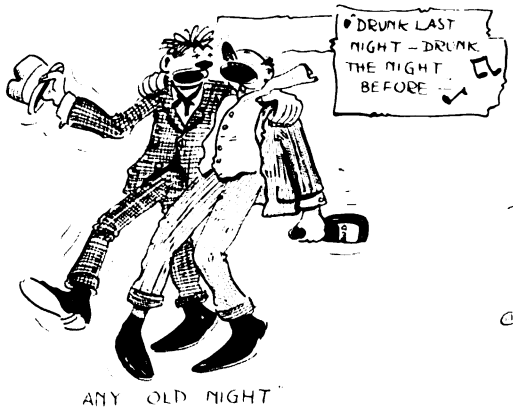
THERE'S A REASON

OH THESE SPRING DAYS!

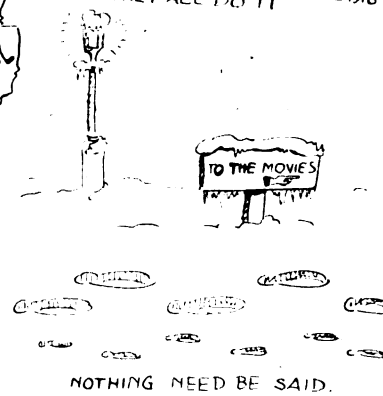


THEY ALL DO IT

LP VAN ZELM 1918



ANY OLD NIGHT



NOTHING NEED BE SAID.

SPARE MOMENTS

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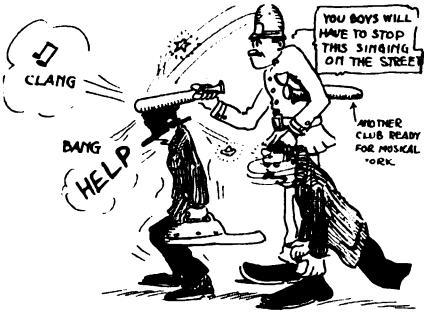
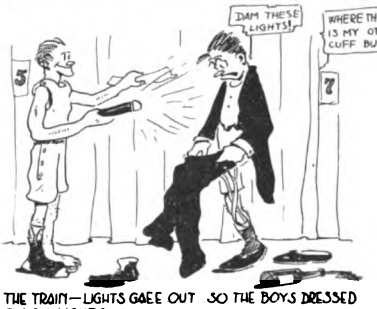
BOUND FOR NEW YORK—ON THE OLD FALL RIVER LINE



THE MUSICAL CLUBS IN NEW YORK

AT PHILLY—E RAYMOND LED THE GRAND MARCH WITH ONE OF THE FAIR DEBUTANTES

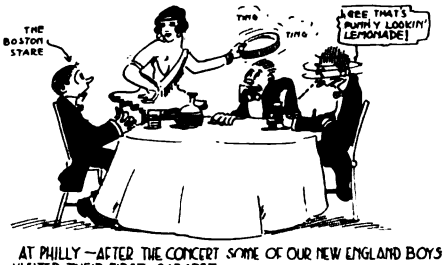
AT —THE DANCE HALL WAS OVER RUN WITH GIRLS



ON THE TRAIN—LIGHTS GAEE OUT SO THE BOYS DRESSED BY FLASH-LIGHTS

IN NEW BRITAIN—PERHAPS MGR. WEN FORD CAN TELL US ABOUT THE GERMAN MASQUERADE, HIS PLEASURE AS ESCORT ETC. ETC - ASK HIM!

AT PITTSFIELD—SHORTY CARR GAVE OUT THE FAVORS



AT PHILLY—AFTER THE CONCERT SOME OF OUR NEW ENGLAND BOYS VISITED THEIR FIRST CABARET

"A FEW NOTES FROM THE MUSICAL CLUB'S TRIP"

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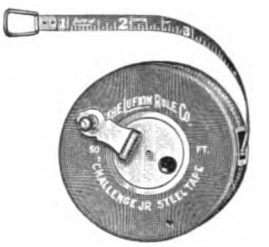

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She—What was the first legal document in history?

He (smart young lawyer)—Why—er—I don't remember.

She—The "lien" on the Tower of Pisa.—The Medley.

Mrs. Latelyhitched—Why, John, are you drunk?

Mr. Latelyhitched.—Well, m'dear, if I'm not I've been cheated.—Widow.

"Say, Alabama is a dry state, isn't it?"

"Sure."

"Why, when I was there, I saw several negroes who were intoxicated."

"Well, of course, they can't stop the sale of that awful cotton gin entirely."—Widow.

FULL SPEED AHEAD

He was the slowest boy on earth, had been sacked at three places in two weeks so his parents apprenticed him to a naturalist. But even he found him slow. It took him two hours to give the canaries their seed, three to stick a pin through a dead butterfly, and four to pick a convolvulus. The only point about him was that he was willing.

"And what," he asked, having spent a whole afternoon changing the goldfishes' water, "shall I do now sir?" The naturalist ran his fingers through his locks. "Well, Robert," he replied at length, "I think that you might now take the tortoise out for a run." —Ex.

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Frantically she dashed into the room and threw herself upon him. Her hand closed tightly upon his wrist—the glittering blade he held wavered and fell. There was a look of terrible rage in his eyes as he turned upon her.

"Don't!" she gasped.

"Why not?" he asked thickly.

"Jim cut his corns with that this morning," she breathed. "You'll have to shave with the safety!"—Punch Bowl.

L'ENVOI

A lot of maidens wish
I would only tell them where
They can spill Gefullte Fisch
On a multimillionaire.—Columbia Jester.

She—Are you a New Yorker?

He—No! I'm a Philadelphian, pure and simple!

She—Humph! That's true!—Punch Bowl.

Mother—I am surprised at you! I heard him kiss you twice!

Daughter—Nonsense, mother! That must have been the echo!—Punch Bowl.

THIRTY YEARS

Pacifist's Wife—A large piece of steak, please.

Butcher—What price?

P. W.—A piece at any price.—Punch Bowl.

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Consider the purchase of an instrument as an investment--you buy it for many years' service.

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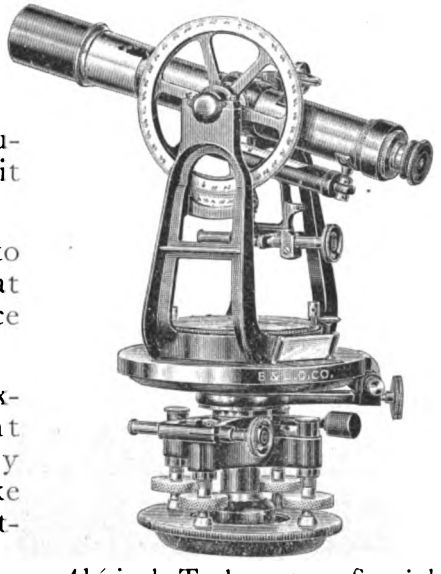
Write for Metro Manual--our new handbook of unusual value to the engineer.

Compare with other instruments--then buy



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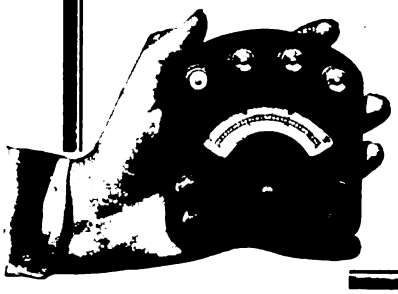

The group includes Portable Volt-Meters, Millivoltmeters, Volt-Ammeters, Ammeters, Mil-Ammeters in single, double and triple ranges; Battery Testers, and Switchboard Voltmeters, Volt-Ammeters, Ammeters and Mil-Ammeters. The several models and ranges offer a selection from over 300 different combinations.

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THIS APPLIES AT TECH

"Say, Professor, I don't think I deserved zero on that paper!"

"You didn't, but I couldn't give you less!"—Punch Bowl.

NOT SO RECKLESS

"As I understand it, you lecture on the subject of 'Peace at any Price'?"

"No, my rates are $200 per lecture." Louisville Courier-Journal.

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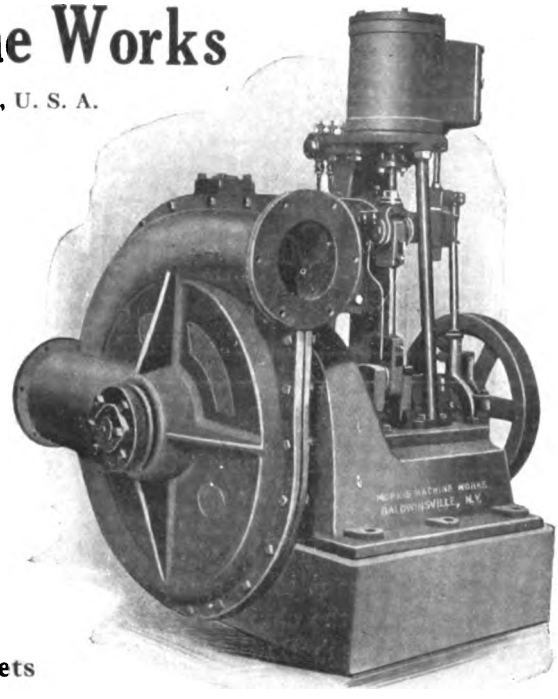

POOR POP

'Twas the night after Christmas, when all through the house
Not a creature was stirring excepting a mouse,
And dearest papa, who sat long at his table,
Appraising the cost of the Santa Claus fable,
With pencil in one hand, his bills in the other,
He was patiently trying his curses to smother.—Punch Bowl.

She—Mr. Brown, can you tell me roughly what time the show is over?

He—Yes, you insignificant, measly little pest. About 10.30.—Minn. Minnehaha.

"Can a human being be classified as a piece of furniture?"

"Well, last night I was abed, and—" (And the tempestuous waves beat angrily against the rocks.)—Jack-o'-Lantern.

Pa snores like fifteen buzz-saws.
Last night my ma, she shout:
"Now Pietro, you go downstairs
And put that darn IVd out."—Punch Bowl.

It is quite likely that at Christmas time the trenches in Europe will be decorated with many highly colored balls.—Punch Bowl.

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NEW YORK BOSTON CHICAGO

Bryan is some Santa Claus. It is not hard to imagine him filling up his Christmas talking.—Punch Bowl.

Preparedness means to be ready with a basket to catch the chip knocked off the shoulder.—Punch Bowl.

Lucille—Has he written regularly since you became engaged?

Eleanor—No! Sometimes I only get one letter a day!—Punch Bowl.

"Why is a music store like a bank?"

"Because notes are the soul of both."—Punch Bowl.

The widow and her children approached the local photographer.

"What are your rates, please?" she inquired.

"Seven-fifty a dozen, Madam," he replied.

"But I have only eleven."—Jester.

AT THE DANCE

She—Let's sit down, I have a sprained knee.

He (absently)—So I see.

She (horrified)—You brute, you do not; I'm going home.

Exit he.—Lehigh Burr.

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HOLDING THE FORM

The newspaper humorist went courting. He stayed late, very late, so late that the old man called down to his daughter, "Phyllis, hasn't the morning paper come yet?"

"No, sir," answered the funny man, "we are holding the form for an important decision."

And the old man went back to bed wondering if they would keep house or live with him.—Boston Transcript.

NEWSPAPER WAIFS

Persistent.—"Be sure and get the right tooth, doctor." "Don't worry. I'll get it if I have to pull out every tooth in your head."—Life.

"Do you suffer from the climate?" "Yes. I know a man from California who refuses to talk about anything else."—Washington Star.

"Have you a stove-lifter I could borrow?" asked the woman who had just moved in. "I'm sorry to say I haven't, but my husband is a piano mover," suggested the woman next door."—Judge.

Bride-to-Be.—"I hope, dear, we won't get any duplicate wedding presents."

Groom-to-Be.—"Oh, I don't know. Dad's promised us a $5,000 check, and I wouldn't mind getting a duplicate from your father."—Boston Transcript.

"Now, wife, if we are going into the poultry business here is an opportunity. Neighbor Wombat has some hens he will sell us cheap." "Oh, I wouldn't get second-hand fowls. Better start with new models, I say."—Louisville Courier-Journal.

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